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P. 254, line 24 . . . . For *kuntzii* read *combsii*

P. 273, line 28 . . . . For *Atypus* read *Pachnaeus*

P. 278, line 17 from bottom . . . For DENSORE read DENSMORE

JOURNAL

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MATHEMATICS.—*A mathematical note on the annealing of glass.*[1] E. D. WILLIAMSON, Geophysical Laboratory, Carnegie Institution of Washington.

In a recent paper[2] Adams and Williamson have discussed at some length the annealing of glass. It is not the object of the present note to revise the deductions made from the experimental data but rather to show how the mathematical treatment of the equations representing these deductions may be made more rigorous. The immediate practical aim is to discover whether this course will indicate a possible procedure by which the time spent in the annealing process can be materially shortened. We shall anticipate by saying that this is found to be the case and a fifteen per cent reduction of time can be made. A future communication will give detailed schedules for vaious types of glass on this new basis.

The problem to be solved may be stated as follows. A block of glass is found to be in a condition of internal strain. By holding it at a temperature somewhat below the softening point the strain may be removed at a rate depending on that temperature. Further strain will be added during the cooling process due to temperature differences set up in cooling. It is required to find at what temperature to hold the glass, how long to hold it at that temperature (or, what is the same thing, to what degree of completeness to remove the strain) and how rapidly to cool at every point in the course of cooling so that the least possible time be taken consistent with the final strain being inside the allowable limits.

The notation used is that of the paper already cited.

θ = temperature in degrees Centigrade.

θ_0 = temperature at which glass is held to remove strain.

[1] Received November 15, 1921.

[2] L. H ADAMS and E. D. WILLIAMSON. Journ. Franklin Inst. 190: 597–631; 835–870. 1920.

h = cooling rate in degrees per minute.
h_0 = initial cooling rate at θ_0.
N = total strain allowable in optical units.
ΔN_a = strain left in glass after holding at θ_0.
ΔN_c = strain introduced by temperature differences in cooling.
t_a = annealing time = time the glass is held at θ_0.
t_c = time spent in cooling.
A = annealing constant as found in table 3, *op. cit.*
A_0 = value of A at θ_0.
c = constant, depending on the type of glass, defined by equation (10), page 841, *op. cit.*

The last part of the problem will be solved first. That is, if the glass has been held at θ_0 till the strain is reduced to ΔN_a how must it be cooled so that t_c may be a minimum consistent with the final strain being N, or in other words, having $\Delta N_c = N - \Delta N_a$?

$$t_c = -\int_{\theta_0}^{\theta} \frac{d\theta}{h} \text{ and } N - \Delta N_a = \Delta N_c = -c^2 \int_{\theta_0}^{\theta} A \frac{\left(h - \frac{\Delta N_a}{c}\right)^2}{h} d\theta$$

the latter being the integral of equation 12 in the previous paper which depends on the experimental results set forth there. Applying the calculus of variations to find h as a function of θ yields

$$\text{const.} \frac{d}{dh}\left(\frac{1}{h}\right) - A \frac{d}{dh} \frac{\left(h - \frac{\Delta N_a}{c}\right)^2}{h} = 0$$

$$\text{or } A \left(h^2 - \frac{\Delta N_a^2}{c^2}\right) = \text{constant} = A_0 \left(h_0^2 - \frac{\Delta N_a^2}{c^2}\right). \qquad (1)$$

Now it is shown in the previous paper that

$$A = A_0 . 2^{\frac{\theta - \theta_0}{10}}.$$

$$\text{Therefore } \left(h^2 - \frac{\Delta N_a^2}{c^2}\right) = \left(h_0^2 - \frac{\Delta N_a^2}{c^2}\right) 2^{\frac{\theta_0 - \theta}{10}}.$$

Equation (1) shows how the rate may be increased as the temperature drops, and h_0, the initial rate, may be found by the condition that $\Delta N_c = N - \Delta N_a$. The time consumed will then be the minimum

possible under the conditions of the problem. An example of how the cooling rate changes is found in table 1.

The problem may now be restated. t_a is a function of A_o and ΔN_a, and t_c can also be expressed in terms of these by means of equation (1) and the proper value of h_o, that is, provided the necessary integrations can be carried out. Can values of A_o and ΔN_a be chosen so that $(t_a + t_c)$ may be a minimum?

$$\text{Now } t_c = -\int_{\theta_o}^{\theta} \frac{d\theta}{h}$$

$$\text{but } h^2 - \frac{\Delta N_a{}^2}{c^2} = \left(h_o{}^2 - \frac{\Delta N_a{}^2}{c^2}\right) 2^{\frac{\theta_o - \theta}{10}}.$$

From the latter, taking the logarithm of each side and differentiating

$$d\theta = -\frac{20\, h dh}{\left(h^2 - \frac{\Delta N_a{}^2}{c^2}\right) \ln 2}.$$

$$\text{Therefore } t_c = \frac{20}{\ln 2}\int_{h_o}^{h} \frac{dh}{h^2 - \frac{\Delta N_a{}^2}{c^2}} = \frac{10\, c}{\Delta N_a \ln 2}\left[\ln \frac{h - \frac{\Delta N_a}{c}}{h + \frac{\Delta N_a}{c}}\right]_{h}^{h_o}.$$

In actual practice the cooling proceeds over a range of several hundred degrees. By this time h is large compared with $\Delta N_a/c$ so that the upper limit of the integral may be taken as containing ln 1 and hence is zero.

The result therefore is

$$t_c = \frac{10c}{\Delta N_a \ln 2} \ln \frac{h_o + \frac{N_a}{c}}{h_o - \frac{N_a}{c}}$$

in which h_o has yet to be determined by the condition

$$N - \Delta N_a = -c^2 \int_{\theta_0}^{\theta} A \frac{\left(h - \frac{\Delta N_a}{c}\right)^2}{h} d\theta.$$

Making the same substitution as before for $d\theta$, and remembering that $A = A_\circ 2_\circ^{\frac{\theta - \theta_0}{10}}$, the integration is simple, and yields

$$N - \Delta N_a = \frac{20\ c^2 A_\circ \left(h_\circ - \frac{\Delta N_a}{c}\right)}{\ln 2}.$$

Taking the value of $h_\circ$ from this and substituting in the value of t_c, we get

$$t_c = \frac{10\ c}{\Delta N_a \ln 2} \ln \left[\frac{(N - \Delta N_a) \ln 2 + 40\ cA_\circ\ \Delta N_a}{(N - \Delta N_a) \ln 2}\right].$$

We shall assume that the original strain in the glass is so large that its reciprocal is negligible compared with $\frac{1}{\Delta N_a}$. Then by equation (7*c*) in the previous communication

$$t_a = \frac{1}{A_\circ\ \Delta N_a}.$$

Therefore $t_a + t_c = \frac{1}{A_\circ\ \Delta N_a} + \frac{10c}{\Delta N_a \ln 2}$

$$\ln \left[\frac{(N - \Delta N_a) \ln 2 + 40 cA_\circ\ \Delta N_a}{(N - \Delta N_a) \ln 2}\right].$$

Partial differentiation with respect to $A_\circ$ and ΔN_a yields two equations as conditions for $(t_a + t_c)$ having a minimum value. After a little simplification these take the form

$$580\ \Delta N_a c^2 A_\circ^2 = (N - \Delta N_a) \ln 2 + 40\ \Delta N_a c A_\circ$$

$$\text{and } \ln \left[\frac{(N - \Delta N_a) \ln 2 + 40\ \Delta N_a c A_\circ}{(N - \Delta N_a) \ln 2}\right] = \frac{\Delta N_a \ln 2}{(N - \Delta N_a)\ 10\ cA_\circ}.$$

The form of the second equation makes it necessary to use an approxi-

mate solution. A sufficiently close one is

$$cA_\circ = 0.075$$
$$N_a = 0.725\, N.$$

If, then, we know c, the constant which depends on the elastic properties of the glass, and have a table like table 3 in the older paper showing the values of A for various temperatures, the required problem is completely solved and one can say definitely that the glass must be held a certain temperature for a certain time and be cooled at a predetermined rate at every instant of its cooling in order that the necessary conditions may be fulfilled.

The total time necessary for the process is

$$\frac{c}{0.075 \times 0.725\ N} + \frac{c}{0.075 \times 0.275\ N} = 66.9\frac{c}{N}.$$

In computing this the value of t_c was simplified by means of the second conditional equation.

As an illustration the case of a slab of plate glass 2 cm. thick will be treated. This is the same example that was previously used to illustrate four different procedures. In this case c is about 13 and we shall suppose $N = 5$ as in the older work. Then $A_\circ = \frac{0.075}{13} =$ 0.0058, and reference to figure 12, in the original, places this at about 520° C., which is 6° higher than in the fastest previous schedule. ΔN_a will be equal to 3.625. The glass must be held at this temperature for $\frac{1}{0.0058 \times 3.625} = 47.6$ minutes, and the total time will be 174 minutes or a little better than 15 per cent less than in the best previous schedule.

The initial rate of cooling $h_\circ = \frac{(N - \Delta N_a) \ln 2 + 20\, cA_\circ\ \Delta N_a}{20\, c^2 A_\circ}$ = (in this case) 0.33° per minute. The table shows how that rate increases as the temperature drops.

We have been asked recently how long a time is necessary for annealing a sheet of glass 25 feet in diameter and 2 feet thick. If the glass be one for which the constants are known the question can be easily answered. Suppose the glass is of the same type as in the previous example, then c will be approximately 13×30^2. The final

allowable strain in this particular case was given as $N=20$. We then find

$$t_a = \frac{13 \times 30^2}{0.075 \times 0.725 \times 20} \text{ minutes} = 10760 \text{ minutes} = 7.5 \text{ days.}$$

$$\text{Total time} = 66.9 \times \frac{13 \times 30^2}{20} \text{ minutes} = 39140 \text{ minutes} = 27.2 \text{ days.}$$

$$A_o = \frac{0.075}{13 \times 30^2} = 0.0000064.$$

Therefore $\theta_o = 419°$ C. (see table 5 and equation (8), *op. cit.*), and

$h_o = 0.33 \times \frac{4}{30^2} \times 1440°$ C. per day $= 2.11°$ C. per day. The glass should therefore be held at 419° C. for seven and one-half days and then cooled, the initial cooling rate being a little over 2° per day and increasing as in the table.

TABLE 1.—Schedule According to Which the Cooling Rate Should Be Increased

Initial rate	1.00
Rate after 10° cooling	1.12
Rate after 20° cooling	1.36
Rate after 30° cooling	1.73
Rate after 40° cooling	2.30
Rate after 50° cooling	3.15
Rate after 60° cooling	4.36
Rate after 70° cooling	6.12
Rate after 80° cooling	8.60
Rate after 90° cooling	12.15
Rate after 100° cooling[a]	17.14

[a] In the later part of the range the cooling-rate practically doubles every 20°.

SUMMARY

From the equations representing the results of experimental work previously described, the most favorable conditions for annealing a given piece of glass can be deduced. Formulas are found which, used in conjunction with tables of the elastic and annealing constants of the glass, show at what temperature to hold the glass, how long to hold it at that temperature, and how rapidly to cool it in order to get any degree of fineness of annealing in the least possible time. Examples are solved to illustrate the processes.

MINERALOGY.—*Gillespite, a new mineral.*[1] WALDEMAR T. SCHALLER, U. S. Geological Survey.

A small rock specimen collected from a moraine near his claim near the head of Dry Delta, Alaska range (about 100 miles S. E. of Fairbanks), Alaska, by Mr. Frank Gillespie (after whom the mineral is named) of Richardson, Alaska, was brought to the Chemical Laboratory of the U. S. Geological Survey by Dr. Philip S. Smith of the Survey.

The rock specimen is composed chiefly of a mica-like mineral (gillespite), with a striking red color, which could not be identified by simple tests. By chemical analysis the mineral proved to be a silicate of ferrous iron and barium with the composition $Fe''BaSi_4O_{10}$. Two other minerals, a grayish green diopside and a white barium feldspar, with the red gillespite, compose the rock. Several other minerals are seen in thin sections but only in very small quantities. The mode of occurrence of the rock is not known but it suggests contact metamorphism with the development of abundant barium minerals.

The red gillespite forms thick scaly masses from one to five millimeters across and nearly as thick. The rock mass is compact and although no crystal faces except the basal plane could be detected, thin sections of the rock suggest an occasional terminal plane on a gillespite. The mineral does not scale off like mica but the basal cleavage is very well developed. The physical properties are: brittle, H. = 4, sp. gr. = 3.33. Luster vitreous, color red, streak pink. The color is close to Ridgway's[2] "Pomegranate Purple," Pl. XII, hue no. 71, tone *i*, and to "Spinel Red," Pl. XXVI, hue no. 71, tone *b*. The powder approaches "Geranium Pink," Pl. I, hue no. 3, tone *d*. Translucent. Optically uniaxial, negative, birefringence very low, strongly pleochroic. Refractive indices: ϵ (rose red) 1.619, ω (pale pink to nearly colorless) 1.621.

In the blow-pipe flame, gillespite fuses easily and quietly to a black non-magnetic globule. Heated in a closed tube, it darkens and assumes a deep violet color, the original red color being regained on cooling. Readily decomposed by HCl, without gelatinization, the mineral flakes being changed to glistening flakes of silica which retain the shape of the original mineral. These residues of silica are doubly

[1] Received October 24, 1921. Published by permission of the Director, U. S. Geological Survey.

[2] R. RIDGWAY, *Color standards and color nomenclature.* Washington, D. C., 1912.

refracting and are being further studied. Sulphuric acid decomposes the mineral with separation of silica and formation of barium sulphate.

An analysis of a hand-picked sample of gillespite, with only a few per cent of other mineral present gave the following results:

Analysis of gillespite		Ratios	
SiO_2	50.08	0.831	4.034 or 4 × 1.01
FeO	14.60	0.203	0.985 or 1 × 0.99
BaO	31.02	0.202	0.980 or 1 × 0.98
Al_2O_3	0.34		
Fe_2O_3	0.56	0.008	....
Mn_2O_3	0.14		
Insoluble	2.20		
Water[a]	0.82		
	99.76		

[a] Water determined by "ignition loss" corrected for (assumed) oxidation of FeO to Fe_2O_3. Selected pure fragments of gillespite give no water when heated in a closed tube.

The formula of gillespite is $FeO.BaO.4SiO_2$ or $Fe''BaSi_4O_{10}$. If the ferrous iron and the barium be considered as isomorphously replacing each other, then the formula simplifies to $(Fe'',Ba)Si_2O_5$. There is, however, no evidence for such isomorphous replacement and as the ratios of ferrous iron and barium in the analysis are sharply 1:1, the formula $Fe''BaSi_4O_{10}$ is to be preferred.

The presence of the small quantity of manganese was definitely determined and it is assumed to be present in the strongly chromatic manganic state; the combination of such manganic manganese with possibly a small quantity of ferric iron yielding the deep red color of the mineral. Titanium is not present.

There does not seem to be any group of minerals to which gillespite is closely related, considering its properties and chemical composition.

ICHTHYOLOGY.—*Notice of a spiral valve in the Teleostean fish* Argentina silus, *with a discussion of some skeletal and other characters.*[1] WILLIAM C. KENDALL and DONALD R. CRAWFORD, U. S. Bureau of Fisheries.

INTRODUCTION

Distribution.—*Argentina silus* is found rather infrequently along the Atlantic coast of the United States, although it is not rare off the coast of Norway. The flesh is edible, but *Argentina silus* is not taken in sufficient quantities to be of economic importance.

[1] Received November 19, 1921.

The following are the only records known to us of the capture of the species on the Atlantic coast of the United States. A specimen was found in the stomach of *Physis tenuis* taken off Sable Island in 200 fathoms, which is recorded by Goode and Bean as type number U. S. N. M. 21624, "*Argentina syrtensium*" (Proc. U. S. Nat. Mus., 1878, page 261), and in Oceanic Ichthyology, page 52, as *Argentina silus*.

In July, 1891, a specimen 18 inches long (U. S. N. M. No. 43708) was caught by a boy with a hook and line in the harbor of Belfast, Maine. (Goode and Bean, Oceanic Ichthyology, page 52.) Another, No. 37801, 15 inches (381.0 mm.) long, was taken at Biddeford Pool, Maine (loc. cit.), March 19, 1886.

In 1904, Mr. John R. Neal, of Boston, Mass., sent in for identification by the U. S. Bureau of Fisheries a specimen about 13.5 inches (342.9 mm.) long, taken by a fisherman probably on Georges Bank, September 19 of that year. Another specimen in the collection of the U. S. National Museum, No. 55636, was found at Fletchers Neck, near Ocean Beach, Maine, May 7, 1906.

In the collection of Mr. W. W. Welsh, of the U. S. Bureau of Fisheries, are two young specimens collected on the coast of Maine as follows: 1 specimen 49 mm. long, August 14, 1912, in a closing net at a depth of 35 fathoms, 33 miles north from Mt. Desert Rock. Another, 38 mm. long, August 13, 1913, 25 miles N. E. from Petit Manan light, somewhere above a depth of 110 fathoms.

In December, 1912, a specimen about 15 inches (381.0 mm.) long was found on Hampton Beach, N. J., and was sent to the Bureau of Fisheries by Mr. B. F. Smart, of the U. S. Life Saving Service.

Early in January, 1914, a specimen nearly 14 inches (355.6 mm.) long was found at Hampton Beach and sent in to the Bureau. These latter specimens form the basis for the observations comprised in this paper.

Habits.—Little is known of the habits of this fish. It has been caught in the north Atlantic from Iceland to the coast of Ireland,[2] in rather deep water. The eggs[3] of *Argentina silus* are 3.0 to 3.5 mm. in diameter and are bathypelagic; that is, they float far below the surface where they have been taken in 50 to over 1,000 meters of water.

[2] JOHS. SCHMIDT, *On the Larvae and Post-larval Development of the Argentines* (Argentina silus *Ascan.* and Argentina sphyraena *Linne*). Meddelelser Fra Kommissionenfor Hovunders gelser, Sene Fiskeri, Kobenhavn. **2:** 1–20. Nov. 4, 1906.

[3] *Op. cit.*

It is known that this fish may be caught on bait of mussels (*Mytilus*, according to Nilsson), or on pieces of herring.[4] According to Holt,[5] one specimen caught off the coast of Ireland had in its stomach remains of shrimps and copepods, one of which was identified as *Calamus finmarchichus*, which is known to inhabit the bottom.

VISCERAL ANATOMY

Alimentary Tract and Spiral Valve

The presence of a spiral valve is of considerable interest since up to the present time but one living adult Teleost was known to possess a true spiral valve in the intestine.

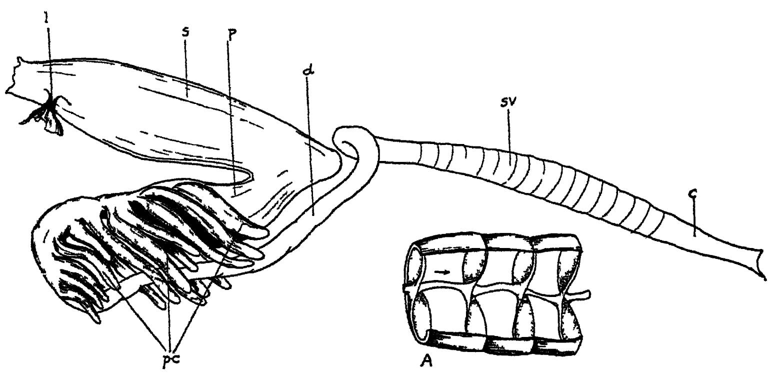

Fig 1. Stomach and intestine of *Argentina silus* × $^2/_3$—*l*, attachment of liver; *s*, cardiac limb of stomach; *p*, pyloric limb of stomach, *pc*, pyloric caeca; *d*, duodenum; *sv*, spiral valve; *c*, rectum. *A*, small portion of spiral valve, with part of the outer wall removed to show internal structure, semi-diagrammatic, × 6.

In *Argentina silus* it has no doubt been overlooked partly because its presence hitherto was unsuspected and also because of the comparatively few specimens available for study. It is not known from the limited material examined whether or not this structure is as variable in different individuals of *Argentina silus* as it is known to be in different individuals of some species of rays and sharks. The two specimens at hand were essentially the same, each showing a true spiral cavity wound around a small central canal. Thus, the

[4] F. A. Smitt, *Scandinavian Fishes*, ed 2, 2: 916. Stockholm, 1895.

[5] W. L. Holt, *The Great Silver Smelt, Argentina silus*, Nilss. *An addition to the List of British Fishes.* Journal of the Marine Biological Association of the United Kingdom. N. S. 5: 341–342. 1897–99.

spiral valve in *Argentina silus* is fully as well developed as it is in the ganoids, among which it is very well developed in *Polypterus* and the Sturgeon, but vestigeal in *Lepidosteous* and *Amia* (*Amiatus*).[6]

It is generally believed that the spiral valve is absent in the more specialized Teleostei with the possible exceptions of *Chirocentrus* and possibly some *Salmonidae*. In making the latter exception reference is made to Rathke's work published in 1824.

In discussing the folds of the mucous membrane lining the intestines of various fishes, Rathke[7] mentions crossfolds (Querfalten) and ringfolds (Ringfalten) as occurring in *Clupea alosa*, the grayling (*Thymallus*), whitefish (*Coregonus*), and *Salmo trutta*. While Rathke evidently was aware of the presence of these folds, it is clear that he did not interpret them as spiral valves, for he does not use the term "Spiralfalten" in this connection as he does in describing the spiral valve of the Sturgeon. The more exact meaning of the term "vestige" still remains to be determined; but at present such a discussion seems to be extraneous. As a matter of fact, however, the writers have found that in some specimens of "Rainbow" trout (*Salmo* sp.) there were six or seven well-developed spiral folds in the posterior end of the intestine which will be discussed more fully in a future paper.

Of the remaining Teleosts in which there are so-called rudiments or vestiges of spiral valves, *Gymnarchus*[8] apparently possesses a slight spiral valve which disappears 43 days after hatching. However, according to Cuvier and Valenciennes,[9] there is a well-developed spiral valve in *Chirocentrus*, one of the *Physostomi*. It is described as follows: "Upon opening the intestine, one finds a mucous lining very remarkable for its exceedingly numerous and close-set folds, which, for the whole extent of the canal, form a series of connivant valves, or rather an internal lamina wound in a very compact spiral—*une lame sur une spirale tres-serée*......" The description is supplemented by a drawing which differs from other drawings[10] of the spiral valve of *Chirocentrus*. However, it is apparent that *Chiro-*

[6] PARKER and HASWELL, *A Text-Book of Zoology*, 2: 218. 1897.

[7] HEINRICH RATHKE, *Über den Darmkanal und die Zeugungsorgane der Fische*, 62–65, 83. 1824.

[8] R. ASSHETON, *The Development of Gymnarchus niloticus*. The Work of John Samuel Budgett. Edited by J. Graham Verr. P. 326.

[9] CUVIER and VALENCIENNES, *Histoire Naturelle des Poissons*, 19: 117; also Pl. 565 between pp. 312–313. 1846.

[10] E. S. GOODRICH, *A Treatise on Zoology*, fig. 77A. Edited by Sir Ray Lankester.

centrus hitherto has been the only Teleost known in which there is a true spiral valve in the adult.

The stomach of *Argentina silus* is siphon-shaped, somewhat like that of a salmon, although the posterior end-curve is conical, suggesting a short caecum. The pyloric limb is the shorter, being about half the length of the cardiac limb.

The duodenum, as it extends forward, curves downward and then upward. It then passes to one side of the stomach near the median line. In the specimen from which the drawing was made (Fig. 1), there were twenty-five pyloric caeca. Just posterior to the stomach, the intestine bends sharply upward and transversely, then backward, after which it runs in a straight line to the anal opening. This part of the intestine is occupied by a well-developed, though simply constructed, spiral valve (Fig. 1*A*). The exterior shows eighteen or twenty transverse septa on a little over two-thirds the length of the straight part of the intestine, but there are several incomplete whorls at the anterior end and a few closely folded ones at the posterior end which do not show externally. Back of the spiral valve, the intestine is a straight tube.

A specimen[11] of young *Argentina silus* 49 mm. long shows a well-developed spiral valve.

The air bladder is thick-walled and silvery, with a small aperture in the posterior end which suggests a pneumatic duct connection but which could not be traced.

SOME SKELETAL CHARACTERISTICS

Cranium.—The most prominent feature in a dorsal view of the cranium is the large frontal bones which extend backward above the eyes and nearly to the posterior margin of the cranium, almost completely covering the parietals. The frontals overlap each other and they are so closely bound together that it is difficult to separate them. When they are removed, the thin and rather narrow parietals are seen lapped underneath these bones. The parietals overlap each other widely and also cover the supraoccipital except for the supraoccipital crest and a narrow posterior margin. The supraoccipital bone is extended foreward into a tongue-shaped process upon which the parietals rest. This process is connected by a cartilaginous bridge

[11] In the collection of Mr. W. W. Welsh, U. S. Bureau of Fisheries. Grampus station 10027. August 14, 1912.

to the sphenotic bones on each side and a narrower ridge extends upward on the inner side of the alisphenoid. There is a cartilage extending downward between parts of the opisthotic[12] and epiotic bones.

The parietals extend laterally and cover the large pit on either side which is bounded by the opisthotics, pterotics, and epiotics. This pit is filled ordinarily by the foreward extension of the large lateral muscles of the body. In *Salmo*, this pit is bounded by the same bones as in *Argentina*, but it is not covered over by the parietals. In *Osmerus*, the pit is bounded by the pterotic and epiotic, the parietals not covering it. Neither do the parietals in *Osmerus* meet in front of the supraoccipital.

The preoperculum falls almost perpendicularly from its fascet. Its two limbs form nearly a right angle, the lower limb which extends forward being as long as the upper, and both are connected at the angle by a heavy flange which is roughly quadrate in outline. The metapterygoids are much reduced. The large mesopterygoids extend downward between the metapterygoids and quadrate bones.

The symplectic extends from the hyomandibular diagonally downward to the top of the lower limb of the preopercle and thence forward. A part of the quadrate bone extends backward on top of the lower limb of the preopercle and overlaps the forward extension of the symplectic. The whole apparatus has the appearance of being drawn downward and forward. There are no teeth on the mesopterygoids,[13] maxillaries, or premaxillaries, but there are small, sharp teeth in single rows on the anterior margin of the vomer and palatines, and a few on the tongue. The preorbital and three suborbital bones extend from the premaxillary backward across the cheek. There is no supplementary maxillary. The premaxillaries are securely fastened to the vomer by connective tissue which makes these bones immovable.

The upper margin of the bones of the lower jaw is strongly arched, the apex of the arch being at the overlapping of the dentary and articular bones. The anterior margin of the dentary is concave and toothless, but it is hard and chisel-edged. Between the dentary and articular bones is a splenial bone, which lies on top of the Meckel's car-

[12] Regan did not recognize the existence of the opisthotic bone in the skull of *Argentina*. It may be seen to best advantage after the frontals and parietals are removed.

[13] There are teeth on the mesopterygoids of *Osmerus*.

tilage. The upper and outer surface of this bone forms a broad contact with the inner surface of the articular. The articular is heavily reenforced on the inner surface at its articulation with the quadrate. The angular bone is present.

Vertebrae.—There are thirty-six abdominal and thirty caudal vertebrae in the vertebral column of our specimens of *Argentina silus*.[14] In the first twenty-one abdominal vertebrae, the neurapophyses are not fused into neural spines and the neural canal is not closed above in the first twenty. The neural canal is closed in the twenty-first, but there are still two neural spines. The parapophyses of the abdominal vertebrae extend outward as rather broad, rhomboidal platforms which lie nearly horizontal, the ribs being attached to the outer corners. The parapophyses become progressively narrower posteriorly and gradually merge into the haemapophyses of the caudal vertebrae. There are ribs on all but the last three abdominal parapophyses. In *Salmo*, the first two abdominal vertebrae do not bear ribs.

Epipleurals are borne on at least twenty-six of the abdominal vertebrae. These bones are ankylosed with the neural spines and may not be separated from them without breaking them apart. The neurapophyses of these vertebrae are articulated loosely to the centra and each may be lifted off of the centrum with the attached zygapophysis and epineural. In those vertebrae which do not bear epineurals, the neurapophyses are ankylosed with the centrum. None of the epipleurals of *Salmo* or *Osmerus* are ankylosed with the neurapophyses.

In the caudal vertebrae, the haemal arch is closed, but in the first nine, the haemapophyses extend downward separately, but they are bridged across by an arch instead of a solid, straight-edged connection, as in *Salmo*. They increase in length posteriorly and taper inward toward each other until, in the tenth, there is a single haemal spine. The 45th vertebra is shown in figure 2, *E*. The last undoubted vertebra is much like that of *Osmerus*. The caudal stylus is composed of elements extending from the upper and lower sides of the centrum whose axis is directed slightly upward. The upper element of the stylus is the heavier, while the reverse is true in *Osmerus*. However, there are three rather indistinct vertebrae whose axes are directed

[14] The following numbers of vertebrae in *Argentina silus* are recorded in various ichthyological works: Day, 65; Smitt, 65–68; A. Schubberg, 66.

upward posterior to the stylus, while in *Osmerus* this is not the case. (Fig. 2, *D*.)

Pelvic Bones.—The pelvic bones differ widely from those of other Isospondyli. There is one distal pterygiophore loosely articulated to the basipterygium. Above it, there is a large, spheroidal swelling of hard bone excavated on the inner side to which the first ray is articulated. From this spheroidal swelling, a slender shaft projects

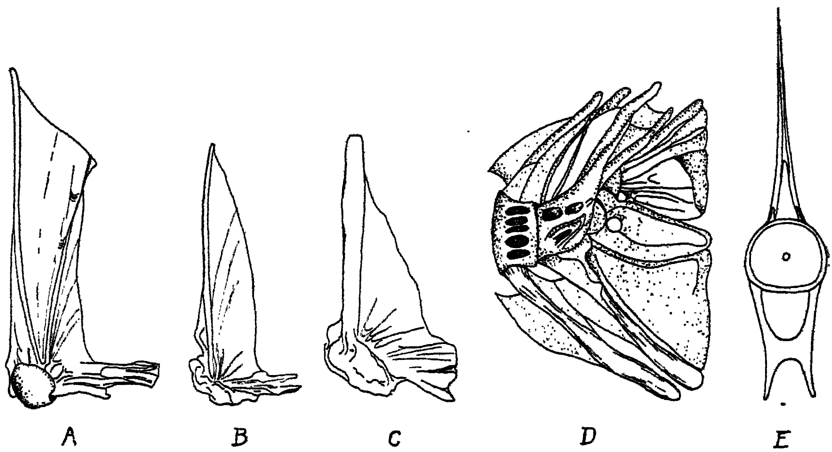

Fig. 2. *A*, basipterigium of *Argentina silus*, × 1½; *B*, basipterigium of *Osmenus mordax*, × 3; *C*, basipterygium of *Salmo sebago*, × 2; *D*, caudal vertebrae of *Argentina silus*, × 2; *E*, 45th vertebrae of *Argentina silus*, showing the arched connection between the haemopophyses, × 2.

forward along the margin and another shaft, originating at the base of the first, runs diagonally forward across the basipterygium. The anterior margin of the basipterygium extends diagonally across the ends of the two shafts, the whole bone being trapezoidal in shape, as shown in figure 2, *A*. In this respect, it differs from the basipterygia of other Isospondyli which are roughly triangular in outline. (Fig. 2, *B*, *C*.) A lateral process extends inward to meet a similar process on the opposite side.

Pectoral Girdle.—There is no postclavical such as that found in a salmonid. The actinosts are thin, but they are connected by webs of bone. The mesocoracoid is present and well developed. The supratemporal is a thin, blade-shaped bone loosely attached to the upper posterior margin of the supraoccipital. Of the two processes of the posttemporal bone, the lower which curves downward is the

longer. It is firmly attached to the base of the exoccipital by tough connective tissue.

The pectoral girdle is further attached to the skull and vertebrae by three rod-like ligaments on each side. The upper ligament passes from the posttemporal to the basioccipital. The second is attached to the supraclavical and the first vertebra which is ankylosed with the skull. The third ligament attaches the clavical to the second vertebra, or the first which is not ankylosed with the skull.

Scales.—The scales of *Argentina silus* differ greatly from those of *Osmeridae* or *Salmonidae.* In these two families, the scales are smooth and cycloid, but in *Argentina silus* they are roughened by small spines, and they are ctenoid in a manner similar to certain clupeids and percids (Menhaden and *Stizostedion*). The heart-shaped scales as described by Smitt appear only along the lateral line.

SUMMARY OF CHARACTERISTICS OF *Argentinidae* AS INDICATED BY *Argentina silus*

Visceral characteristics

Stomach bluntly caecal; intestine *with well-developed spiral valve;* pyloric caeca much less numerous than in *Coregonidae,* not much less numerous than in *Salmonidae,* and much more numerous than in *Osmeridae;* air bladder thick and silvery; pneumatic duct, if any, connected with its posterior end.

Skeletal characteristics

Cranium:—Frontals extend backward overlapping parietals, nearly covering them. Parietals overlapping on top of supraoccipital; opisthotic present; splenial bone present in lower jaw; mesopterygoids and jaws toothless; no supplementary maxillary.

Vertebrae:—66 all told. Double neural spines in first 21, canal being open in first 20. Ribs on all but last three abdominal vertebrae. Osseous epipleurals on at least 26 abdominal vertebrae; these are ankylosed to zygapophyses and neural spines; haemapophyses of abdominal vertebrae bridged by arch instead of straight-edged piece as in *Salmo;* pelvic bones with trapezoidal instead of a triangular basipterygium.

Pectoral girdle:—With no postclavical process and with thin actinosts which are connected by webs of thin bone.

Scales:—Ctenoid. Modified along lateral line.

SYNOPSIS AND REVIEW OF THE HISTORY OF THE CLASSIFICATION OF *Argentina*

The statement by Linnaeus that there are teeth on the jaws and tongue[15] ("*Dentes* in maxillis, lingua") is not borne out by Artedi[16] to whom Linnaeus refers, or by subsequent descriptions. Artedi says teeth on tongue and palate ("*Dentes* in lingua & Palate"). Furthermore, Linnaeus states the branchiostegal rays as 8. Artedi does not mention the number but all subsequent descriptions state them as 6. While Linnaeus does not mention the number of pyloric caeca it is interesting to note that Artedi says that there are 6 or 7. Both of the foregoing refer to the Mediterranean species *Argentina sphyraena*.

In their discussion of the genus *Argentina*, Cuvier and Valenciennes indefinitely mention numerous caecal appendages[17] and state that the stomach ends in a cul-de-sac. The genus is included in "Salmonoides." Gunther[18] says: Pyloric appendages in moderate numbers. He refers the family to *Salmonidae*, which includes *Salmo, Oncorhynchus, Brachymystax, Luciotrutta, Plecoglossus, Osmerus, Thaleichthys, Hypomesus, Mallotus, Retropinna, Coregonus, Thymallus, Argentina*, and *Microstoma* comprised in the first group Salmonina, in the order named.

In recognizing the subfamily *Argentininae* of Bonaparte, Gill states that it differs from *Salmoninae* by the stomach ending in a blind sac posteriorly. In this he agrees with Cuvier and Valenciennes. Gill's original observations, however, were apparently on the smelts and allied forms. In the subfamily he recognized two genera, *Argentina* and *Silus*, the first with cycloid, the other with spinigerous scales. Later Gill placed the subfamily *Argentininae*, comprising *Mallotus, Osmerus* and *Microstoma*, also by implication, other Osmerids and *Argentina*, in the family *Microstomidae*.[19] Ten years later, however, Jordan and Gilbert include *Argentina* in the family *Salmonidae*, recognizing no subfamilies in the description of the genus, thus following Gunther.

[15] *Systema Natura:* 315. 1758.

[16] *Ichthyologia,* **5:** 8. 1738.

[17] *Histoire Naturelle des Poissons,* **21:** 299. 1898.

[18] *Catalogue of the Physostomi, British Museum,* p. 202. 1866.

[19] *Catalogue of the Fishes of the East Coast of North America.* Smith. Misc. Coll. **1873:** 11–32.

Without stating any additional characters, Gill, in 1884, established the family *Argentinidae*.[20] By inference the family distinction is that of the caecal stomach.

Smitt[21] retains *Argentina*, as well as the Osmerids, etc., in *Salmonidae*. In his diagnosis of the genus, no character of more than generic value is mentioned. In expressing the relationship of *Argentina* to other forms, however, he says that the odor and few pyloric appendages point to the Smelt and the stiff but fragile fin rays and the singular shape of the scales are reminders of the Scopelids. Also that the peculiarity of the scales suggests the extinct genus *Osmeroides*, which, however, in its numerous branchiostegals and dentition was more like the salmon. Jordan and Evermann accept *Argentinidae*, of Gill, comprising the Osmerids, etc., as well. Their characterization is largely composed of the generic characters of the Osmerids. They state that the stomach is a blind sac, and the pyloric caeca few or none. Following the family diagnosis, the statement is made that there are about ten genera and perhaps a dozen species which are reduced *Salmonidae* smaller and in every way feebler than the trout, but similar to them in all respects except in the form of the stomach.

More recently Regan separated the Osmerids from the *Argentinidae* making for them the family *Osmeridae*, the latter differing from the *Argentinidae* in having toothed mesopterygoids. Both the *Argentinidae* and *Osmeridae* he supposed to differ from the *Salmonidae* in the absence of opisthotics and upturned vertebrae at the posterior end of the vertebral column.

Unless the ensemble of previously designated generic characters of *Argentina* is considered of family rank, no one prior to Regan has enunciated a valid family character, and even he was mistaken concerning the absence of the opisthotic in *Argentina*. However, its presence in *Argentina* and absence from the Osmerids strengthen the family rank of the latter. The fact that *Argentina* possesses opisthotics and vestigial or rudimentary upturned vertebrae, as previously indicated, might be construed by some to show that the genus represents an intermediate between the Osmerids and Coregonids, and even the shape of the stomach as represented by our specimens of *Argentina silus* would support this view. However, there are

[20] Annual Report of the Board of Regents of the Smithsonian Institution for the year 1884 (1885), p. 619.

[21] *Scandinavian Fishes*, 2: 912. 1895.

other characters in which they diverge but in which they should intergrade if they represent true intermediates in a direct line of development. Most of the characters, as well as those mentioned by Smitt and others enumerated in the classifications of *Argentina*, show resemblances merely, rather than actual indications of relationship. And those resemblances represent some of the Salmonoid tendencies of characters possessed by the generalized ancestral form, *Argentina* being a highly specialized terminal product of an early divergent. The fact that it is a comparatively deep water group, of apparently wide distribution, possessing an intestinal spiral valve, considered together with its general structure, would support this view.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*The New Salem lignite field, Morton County, North Dakota.* EUGENE T. HANCOCK. U. S. Geol. Surv. Bull. **726-A.** Pp. 39. 1921.

The New Salem field is part of the great lignite region of western North Dakota and adjacent regions. The history, commercial geography, and surface features of the area are summarized in two pages. Six pages are given to the discussion of the geologic section which includes the Lance and Fort Union formations. Within the Lance is the Cannonball marine member which has been the subject of much recent discussion and is named from the Cannonball River traversing this field. One bed of lignite was found in the Lance below the Cannonball member, but the valuable beds are confined to the upper 200 to 300 feet of the Fort Union.

The beds in most of this field have a very gentle dip (5 to 10 feet to the mile) toward the northwest, with minor folds; in the northwest part of the field they form a gentle syncline. About three pages are given to physical and chemical data and graphic sections of the coal in considerable detail. The heating value ranges about 6,000 to 7,000 calories for coal as mined. Fourteen pages are devoted to a description by townships of the occurrence of the coal in the seventeen townships examined.

MARCUS J. GOLDMAN.

GEOLOGY.—*Ground water in the Southington-Granby Area, Connecticut.* HAROLD S. PALMER. U. S. Geol. Surv. Water-Supply Paper **466.** Pp. 213. 1921.

This paper is the fourth to appear of a series of detailed reports on the ground-water resources of selected areas in Connecticut. The first part is of a general character and treats of the water-bearing formations, occurrence and recovery of ground water, and its quality. This is followed by descriptions of the eighteen towns included in the area, which is partly in the Central Lowland and partly in the Western Highland of Connecticut.

Almost everywhere water may be obtained in small quantities from fissures and joints in the bed rocks which include crystalline rocks of pre-Triassic age and sandstone, shale, and trap of Triassic age. The till that mantles the bed rock of the hills and upper valley slopes yields in general satisfactory domestic supplies. The stratified drift or glacial outwash deposits of the lowlands yield abundant supplies of water except in the more unfavorable topographic situations.

Maps show the distribution of the water-bearing formations, the distribution of woodlands, and the locations of the wells and springs referred to in the tables in the text.

HYDROLOGY.—*Ground water for irrigation near Gage, Ellis County, Oklahoma.* DAVID G. THOMPSON. U. S. Geol. Surv. Water-Supply Paper **500-B.** Pp. 21. 1921.

This paper contains a brief description of the geology and occurrence of ground water in a part of Ellis County in western Oklahoma. The region is in the semi-arid belt and in years when the precipitation is deficient crops may fail. In August, 1918, in a well that was being drilled for oil near Gage a large flow of artesian water was struck, which it was hoped could be used for irrigation. Investigation showed that the water comes from the Permian "Red Beds" and, although in sufficient quantity, it is generally so highly mineralized that it cannot be used for irrigation. Water of good quality can be obtained from the Tertiary rocks, but these rocks do not yield enough water to provide for irrigation. The conclusion is reached that water can be obtained for irrigation only along the floodplains of the larger streams in the area. D. G. T.

ORNITHOLOGY.—*Mutanda ornithologica. IX.* H. C. OBERHOLSER. Proc. Biol. Soc. Wash. **33**: 83–84. 1920.

Preoccupied names of five species of birds cause the following nomenclatural changes. The bird commonly known as *Dendrocitta sinensis* (Latham) is renamed *D. celadina.* The name of the wagtail now called *Motacilla longicauda* Rüppell is changed to *M. rhadinura.* The South African warbler, *Eremomela flaviventris* (Burchell), is hereafter to be called *E. griseoflava perimacha.* The Indian babbling thrush that has long been known as *Crateropus griseus* (Gmelin) is renamed *Turdoides polioplocamus,* since in addition to the preoccupation of its specific name, the generic name *Turdoides* Cretzschmar must supersede *Crateropus* Swainson. Furthermore, *Arrenga cyanea* (Horsfield) will henceforth be known as *A. glaucina* (Temminck). H. C. O.

ORNITHOLOGY.—*Unusual types of apparent geographic variation in color and of individual variation in size exhibited by* Ostinops decumanus. F. M. CHAPMAN. Proc. Biol. Soc. Wash. **33**: 25–32. 1920.

Study of *Ostinops decumanus* shows that there are great individual differences in size apparently attributable to age, and this involves a remarkable variation not only in the length but in the shape of the wing chiefly in males. Furthermore, an interesting geographic color variation in which there appear wholly or partly yellow feathers scattered throughout the plumage of the body and wing coverts indicates an undescribed race in Bolivia, which is described as *Ostinops decumanus maculosus.* H. C. OBERHOLSER.

ORNITHOLOGY.—*Food habits of seven species of American shoal-water ducks.* DOUGLASS C. MABBOTT. Bull. U. S. Dept. Agric. **862**. Pp. 67, pls. 7. 1920.

The food of *Chaulelasmus streperus* to a large extent consists of leaves and stems of water plants, and, with the exception of that of *Mareca americana*, includes a larger percentage of vegetable matter than any other species. The food of *Mareca americana* is almost the same as that of the previous species. As many as 64000 seeds of the spike rush (*Eleocharis*) have been noted in a single stomach. The diet of *Mareca penelope* and *Nettion carolinense* is made up principally of water plants and their seeds.

The blue-winged teal (*Querquedula discors*) feeds to a large extent on the seeds and other parts of water plants, although nearly one-third of its food is animal matter, mostly mollusks, insects, and crustaceans. The food of *Querquedula cyanoptera* is very similar.

Vegetable matter comprises about seven-eighths of the diet of *Dafila acuta tzitzihoa*, and this is chiefly seeds and other parts of plants, principally those growing in or near water. Individual birds have been known to consume for a single meal 28000 seeds of *Salicornia ambigua*. The remaining portion of the food of this duck consists of animal matter, such as mollusks, crustaceans, and insects.

The well-known *Aix sponsa* feeds mostly on the seeds and other parts of water plants, on acorns, grapes, berries, and the seeds of trees and shrubs. From a single stomach 10000 seeds of lizard's tail (*Saururus cernuus*) have been taken. About one-tenth of its diet is animal matter, chiefly insects and spiders.

In all, 2888 stomachs of the seven species have been examined, and the various items of food identified in each species are shown in an extended table which closes this bulletin. HARRY C. OBERHOLSER.

ORNITHOLOGY.—*Records of several rare birds from near Washington, D. C.* B. H. SWALES. Proc. Biol. Soc. Wash. **33**: 181–182. 1920.

The following interesting birds are here recorded from the region about Washington, D. C., all except one from specimens obtained: *Colymbus holboellii, Oceanites oceanicus, Phalaropus fulicarius, Numenius americanus, Pluvialis dominica dominica, Coragyps urubu urubu,* and *Aquila chrysaetos*. H. C. OBERHOLSER.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

856TH MEETING

The 856th meeting of the Philosophical Society of Washington was held in the Cosmos Club auditorium, Nov. 19, 1921. It was called to order at 8:20 p.m. by President FARIS with 49 persons present.

The first paper of the evening, on *Dip-needle errors arising from minute pivot defects*, was presented by Mr. H. W. FISK, and was illustrated. It was discussed by Messrs. L. A. BAUER and L. J. BRIGGS.

After all compensating reversals of instrument and needle have been made in determining the magnetic inclination or dip, with a dip circle, there will

be outstanding characteristic differences between results obtained at the same station with two or more needles. These are probably due to irregularity of general form of pivot and are eliminated by applying corrections derived from least square reductions where data are available, or from empirical graphs otherwise.

Occasionally a needle will give a result differing widely from the mean of the others used at the same station, and a critical study of several cases of this kind derived from results of field work in widely separated regions, shows that when not purely accidental, these differences vary with the varying dip as they would if they were caused by a small particle adhering to the pivot of the needle. A method was presented of analyzing the results derived from a series of stations at each of which the dip had been obtained by use of four needles, so that such deviations from the normal value could be readily recognized. Cases illustrating the results of such analysis were presented.

Theory was developed by which it was shown that the occasional differences under investigation could be produced by a very minute particle of rust, and an equation was given by which the diameter and thickness of the particle could be determined. By this method it was found that a minute patch of rust 0.02 millimeter in diameter and 6×10^{-5} millimeters thick, on the pivot of an ordinary Dover dip needle, would produce an error of 6 minutes in arc in the determination of dip at a place where the total magnetic force is 0.55.

An example was given to show that the rust particle might later become detached so that the needle would behave normally at the value of dip. Also it was shown that particles of this kind develop very quickly. From these examples it is concluded that the correction for a dip needle cannot be relied upon permanently at any one place nor be safely transferred to a place where the field has a different direction or intensity without a comparison with such a reliable standard as is afforded by the latest type of portable earth inductor. In case a dip circle must be used, not less than four needles should be employed in order to furnish an improved mean, and to better detect such errors as arise from minute pivot defects. (Author's abstract.)

The second paper on *The latitude of Ukiah and the motion of the Pole* was presented by Mr. WALTER D. LAMBERT and was illustrated. It was discussed by Messrs. L. H. ADAMS and L. A. BAUER.

Prof. A. C. Lawson in support of his explanation of certain earth movements in California brings forward the evidence afforded by the astronomic latitudes at Ukiah, California, one of the stations of the International Latitude Service. These latitudes show an apparent increase of about 0.01 a year, which is explained as an actual shifting northward of the crust at Ukiah relative to its substratum. Ukiah is somewhat outside of the region in which the existence of large earth movements has been proved by the evidence of triangulation executed at different dates. The attempt is made in this paper to see whether the astronomical evidence at Ukiah may properly be interpreted otherwise than as indicating a creep of the surface strata.

It is found that the other stations of the International Latitude Service show increases or decreases of the same order of magnitude as that of Ukiah, the general tendency being toward an increase, a feature especially noticeable toward the end of the period of observation. At Gaithersburg, Maryland, the rate of increase even exceeds that at Ukiah. The universality of these

changes and their apparent dependence on the longitude of the station make it natural to seek an explanation in a displacement of the Earth's Pole toward those stations showing the most rapid increases. It is found that the observed rates of change may be satisfied within reasonable limits by a shifting of the North Pole toward the Equator along the meridian of 77° West of Greenwich at the rate of about 0.0050 second a year combined with a cumulative correction to the average declination of the stars used, a correction varying with the time as the program of stars varies. A brief discussion is given of the geophysical aspects of such a shifting of the Pole.

Certain incidental results of the investigation are also mentioned, in particular a rough confirmation of Helmert's work on the figure of the Earth and its moments of inertia as deduced from gravity observations. Even a rough confirmation is of value on account of the presence in the observed values of gravity of systematic influences due to local geological and topographic conditions, and also on account of the fact that good determinations of gravity are possible only on one-fourth of the earth's surface, that is, on land. The results on the moments of inertia, etc., as deduced from the observations of the International Latitude Service are subject to a correction, probably small but not yet precisely evaluated, for the mobility of the ocean waters. (Author's abstract.)

H. H. KIMBALL, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Mr. A. A. BAKER has been appointed geologic aid in the U. S. Geological Survey, and has been assigned to the Alaskan Division.

Mr. W. N. BRAMLETTE, assistant geologist of the U. S. Geological Survey, has been furloughed from the Survey for several months to take up work with the Department of Marine Biology of the Carnegie Institution of Washington.

Mr. DAVID I. BUSHNELL, JR., is preparing for the Bureau of Ethnology a short account of the Cahokia and other mounds in Illinois, near East St. Louis, Missouri. A unique feature of his report will be aero-photographs of the whole group, the first attempt to obtain bird's-eye views of North American prehistoric mounds from an aeroplane.

Mr. W. O. CLARK has resigned from the U. S. Geological Survey, effective January 1, to accept a position as water-supply geologist with a firm in Honolulu, Hawaiian Islands.

Dr. ARTHUR L. DAY, director of the Geophysical Laboratory, Carnegie Institution of Washington, gave an illustrated public lecture at the Institution on the evening of November 29, on *The eruption of Mount Lassen.*

Prof. CHARLES MOUREU of the College de France and president of the International Union of Pure and Applied Chemistry, and Prof. A. MAYER of the University of Strasbourg, are in Washington as chemical advisers to the French delegation to the Conference on Limitation of Armaments.

Mr. WILSON POPENOE, agricultural explorer for the U. S. Department of Agriculture, returned to Washington in November after a two years' absence in Guatemala, Costa Rica, Colombia, Ecuador, Peru, and Chile.

Mr. PAUL C. STANDLEY of the National Museum left Washington early in December for a botanical collecting trip to Central America under the auspices of the Museum, Harvard University, and the New York Botanical Garden. He will spend several months in Guatemala and Salvador.

Mr. R. W. STONE has been appointed assistant state geologist of Pennsylvania and has resigned from the U. S. Geological Survey, the resignation to be in effect January 1. His headquarters will be at Harrisburg, Pennsylvania.

Dr. GEORGE L. STREETER, director of the Department of Embryology of the Carnegie Institution of Washington, gave an illustrated public lecture at the Institution on the evening of November 22, on *Recent studies on the ear as an organ determining equilibrium.*

Dr. H. U. SVERDRUP, physicist of the Roald Amundsen Arctic Expedition, which recently completed the passage by water north of Siberia, is spending several months as research assistant at the Department of Terrestrial Magnetism, Carnegie Institution of Washington. He is taking part in reduction of magnetic observations already taken and also preparing for new series of magnetic, oceanographic, meteorological and other observations to be taken on the continued expedition across the north Polar Sea to be begun by the Amundsen party in the spring of 1922.

Secretary C. D. WALCOTT of the Smithsonian Institution has been elected a corresponding member of the Société Géologique de Belgique, of Liège, Belgium.

Mr. CHUNG YU WANG, consulting mining engineer and geologist, is one of the technical councilors with the Chinese delegation to the Conference on Limitation of Armaments.

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VOL. 12 JANUARY 19, 1922 No. 2

ZOOLOGY.—*The evolution of the animal body.*[1] AUSTIN H. CLARK, U. S. National Museum.

In a recent number of this JOURNAL[2] I gave a brief synopsis of the steps in the evolution of animals based upon the progressively increasing complexity of structure correlated with increased economic efficiency. The subject was treated in much greater detail in a later paper.[3]

Superposed upon this evolutionary line there is another having to do with the development of the body as a whole instead of with the refinement of its internal organization, and to a large extent the two are quite independent.

All the higher animals are ultimately derived from an attached animal colony within which the component zooids are more or less differentiated for the better performance of certain more or less definite functions, this animal colony being in general comparable to the colony of phytons known as a flowering plant.

In the sponges the colonial nature of the animal is evident, but there are no definite organs or tissues, and the mass is imperfectly or not at all divided. The sponges are thus comparable to certain of the so-called thallophytes.

The coelenterates have a definite body structure and are fundamentally colonial, the colony being produced asexually by budding and the component individuals usually showing more or less differentiation into (*a*) nutritive, (*b*) reproductive and (*c*) excretionary ("defensive") types, the latter bearing numerous cells containing a secretion and also a coiled tubule. Free living coelenterates occur, and these arise (1) through the assumption of a free floating existence by the colony as a whole (siphonophores), or (2) through the partial (medusae of hydroids) or complete (*Aurelia*, Trachomedusae, most actinians, etc.) dissociation of the units of the colony.

[1] Received December 16, 1921.

[2] THIS JOURNAL 11: 207–208. May 4, 1921.

[3] Bull. de l'Instit. Océanographique (Monaco), 400: 1–24. 20 septembre, 1921.

The jointed cestodes represent the strobila stage of *Aurelia*, but are somewhat more completely unified, the proglottides sharing a common nervous and excretory system and their detachment being greatly retarded. The pronounced bilateral symmetry of most cestodes and the marked difference in the two sides of the proglottides seen in others together with certain features connected with the budding of the scolex suggest their relationship with the graptolites of which they are possibly the recent representatives.

By a further consolidation and unification of the jointed cestode body correlated with a loss of the individuality of the component segments the annelid body type was evolved, and a further consolidation gave rise to the crustaceans, within which group the tendency is to compress all of the functions of the body within the compass of a few anterior segments, and the insects, in which there are three small groups of segments each with a definite function, (*a*) the head, most unified, controlling and directing, (*b*) the thorax, less unified, locomotor, and (*c*) the abdomen, largest and least unified, enclosing the digestive, reproductive and other organs.

Most crustaceans are more or less, and many are conspicuously, asymmetrical, while in all there is noticeable a great development of the dorsal surface as compared with the ventral. Both of these features are especially characteristic of certain barnacles, become greatly accentuated in the Pelmatozoa, and reach an extreme development in the unattached echinoderms in which the body consists of five half segments only arranged in a circle and enclosed entirely by the dorsal surface, the ventral having almost completely disappeared.[4]

The evolution of solitary animals through the progressive consolidation of a colony correlated with increasing loss of individuality by the component units can thus be traced from the coelenterates through the cestodes to the arthropods and echinoderms.

Closely allied to the cestodes are the trematodes, and from them or from very similar organisms another very different line of development has arisen.

The development of the liver fluke, like that of the tapeworm, in the division of the sporocysts and the subsequent development of cercariae from sporocysts and rediae is comparable in its essential features to strobilization, but the budding takes place, so to speak, within a closed scyphistoma; that is, the sporocysts and rediae undergo

[4] Smith. Misc. Coll. 27: No. 11, 1–20. July 20, 1921.

a sort of invaginated strobilization, the larvae (cercariae, corresponding to ephyrae) finally escaping by the disintegration of the nurse.

The unsegmented cestodes bear approximately the same relation to the tapeworms that *Lucernaria* does to the scyphistoma of *Aurelia*, and the turbellarians in their relations to the liver flukes and their allies are comparable to the Trachomedusae as compared with the colonial coelenterates; that is, they are solitary animals ultimately derived through the dissociation of the units of a primarily colonial type.

Of the remaining acoelomate Eumorphozoa the Polyzoa and Calyssozoa are clearly comparable to colonial coelenterates; the rotifers in their asexual and direct development suggest a fragmented colony while the round worms and the Acanthocephala are solitary, like the Trachomedusae, some cestodes, and the turbellarians.

All other animals agree in the possession of that structure known as a coelome. The coelome, which arises by budding from the enteron, consists of three sections, (*a*) the perivisceral, forming a body cavity, (*b*) the gonadial, and (*c*) the nephridial. There is thus a curious correspondence between the three divisions of the coelome and the three classes into which the polyps of the coelenterates naturally fall, and this suggests the possibility of coelomate animals having arisen through a gastruloid structure resembling a redia by the budding off from the enteron of three units which remained within the gastruloid and there became differentiated into the three types characteristic of the externally budded coelenterate polyps, subsequently undergoing further development.

The priapulids, sipunculids, molluscs, nemerteans, phoronids, brachiopods, chaetognaths, enteropneusts, tunicates, cephalochordates and vertebrates would thus be explained as colonial animals derived from a coelenterate-like colonial type through a process of invagination by which the additional units were produced within the original gastruloid ancestor by budding from the enteron instead of externally as in the coelenterates and polyzoans.

Such an interpretation would account for (1) the entire absence in these groups of that external segmentation so characteristic of the cestodes, the annelids, the arthropods and the echinoderms; (2) the entire absence, except in the enteropneusts and tunicates, which stand quite apart from the other phyla, of all forms of asexual reproduction, this being here represented by internal budding; (3) the almost complete absence of parasitism (occurring only in a very few molluscs and nemerteans), since the transference of the asexual bud-

ding to the interior prevents that prolific asexual reproduction by budding and fission, by parthenogenesis, or by polyembryony always present in those groups in which parasitism is a prevalent condition; and (4) the almost complete absence of attached forms which, except for secondarily attached molluscs, are found only among the brachiopods and the tunicates.

The annelids, in addition to their dominant external segmentation, also possess a coelome, but this becomes greatly reduced in the crustaceans and insects. In the echinoderms, however, the curious distortion leads to a relatively considerable average length for each of the five segments represented, and with this annelidan feature the coelome reappears in a highly perfected form.

The development of the annelids indicates a very close relationship with the molluscs. These two groups thus carry onward the essential differences, as well as the essential similarities, between the cestodes and the trematodes. Similarly the arthropods and the echinoderms appear to be structurally parallel to the nemerteans, phoronids, brachiopods and chaetognaths, the former representing the cestode-annelid, the latter the trematode-priapulid-sipunculid-mollusc type.

The enteropneusts, the tunicates, the cephalochodates (*Amphioxus*, etc.) and the vertebrates are quite unrepresented in the externally segmented line, which culminates in the arthropods and echinoderms. They differ from all other animals in the possession of gill slits or pores. These structures represent the final step in the organization and centralization of the respiratory function and its connection with the endoderm. This is obviously a minor structural detail, presumably of late origin, and as such it suggests that while the other major animal types probably all appeared almost or quite simultaneously the evolution of the forms with gill apertures was considerably delayed.

GEOPHYSICS.—*The latitude of Ukiah and the motion of the pole.*[1]

WALTER D. LAMBERT, U. S. Coast and Geodetic Survey.

In January, 1921, Professor A. C. Lawson of the University of California published an article on earth movements in California.[2]

[1] Presented before the Philosophical Society of Washington, November 19, 1921. Received December 7, 1921. The substance of this paper was also presented at a meeting of the American Astronomical Society at Swarthmore, Pa., December 29, 1921. This paper is based on a longer article by the author entitled *An investigation of the latitude of Ukiah, California, and of the motion of the Pole,* which will appear as a Special Publication of the U. S. Coast and Geodetic Survey.

[2] *The mobility of the Coast Ranges of California, an exploitation of the elastic rebound theory.* Univ. Calif. Publ., Bull. Dept. Geol. **12:** No. 7. Jan. 11, 1921.

His thesis is that there are slow movements of the surface as a result of stresses arising from a subcrustal flow that carries the surface with it. In time these stresses increase to the breaking point; there is then rupture with attendant seismic shocks and a rebound toward the original position.

In support of this thesis Professor Lawson adduces the triangulation executed by the Coast and Geodetic Survey[3] in California at various times before the earthquake of 1906 and during the months immediately following. He adduces also the observed astronomic latitudes at the Ukiah latitude station, one of the stations of the International Latitude Service maintained for the study of the variation of latitude and the motion of the Pole. It should be stated that Ukiah lies outside of the area that was treated as potentially movable in the discussion of the triangulation. The line of greatest disturbance during this earthquake runs along the San Andreas fault; the nearest point of this fault is some 30 miles from Ukiah and not far from the point where the fault itself runs out to sea in a northwesterly direction.

It is not the purpose of this paper to interpret the evidence from the triangulation, but solely to consider the meaning of the astronomic latitudes at Ukiah, which constitute a problem quite independent of the problem presented by the triangulation.

The latitude of Ukiah appears to be increasing with some regularity at a rate not much smaller than 0.01 second per year, that is, a displacement of almost 1 foot or 30 cm. per year. This deduction was made by Professor Lawson from curves given in an article by Sir Frank Dyson,[4] Astronomer Royal of England. It should be said that the curves are used by Dyson for quite a different purpose, and that this increase in latitude is not mentioned by him, nor would its existence affect his results to any perceptible degree. It should be said on the other hand that an apparent increase of this sort is very evident from a mere inspection of the curve for Ukiah, which is shown in figure 1.

As is well known, the two principal periodic terms in the expression for the variation of latitude have periods of one year and of about 14 months. The curve shows the observed variation of latitude with the effect of the annual term removed by computation. The annual term was deduced by harmonic analysis from the observed latitudes at Ukiah only and is therefore independent of any assumption as to the

[3] J. F. HAYFORD and A. L. BALDWIN, *The earth movements in the California earthquake of 1906.* U. S. Coast and Geod. Surv. Ann. Rept. 1907, App. 4.

[4] F. W. DYSON. Month. Not. Roy. Astr. Soc. 78: 452. 1918.

motion of the Pole other than the mere lengths of the periods concerned.

If the variation of latitude conformed to the simplifying assumptions that we often make, the curve would be a simple sine curve with constant amplitude and with its phase changing at a uniform rate. There is, however, a marked increase in the amplitude although the phase change is nearly uniform. The ordinate represents, not the observed latitude itself, but the difference, $\Delta\phi$, between the observed latitude and an arbitrary but fixed initial latitude. The initial latitude is such that near the beginning of the period this conventional zero line of $\Delta\phi$ coincides very nearly with the true zero line, or line running midway between the points of maximum and minimum. Towards the end of the period the curve has shifted so much that most of it lies above the conventional zero line. The angle between the true zero line and the conventional zero line represents the rate of increase of the mean latitude, that is, of the latitude freed from the effects of all known periodic terms. This slope or rate Professor Lawson determined by a graphic adjustment; he drew a straight line passing as near as possible

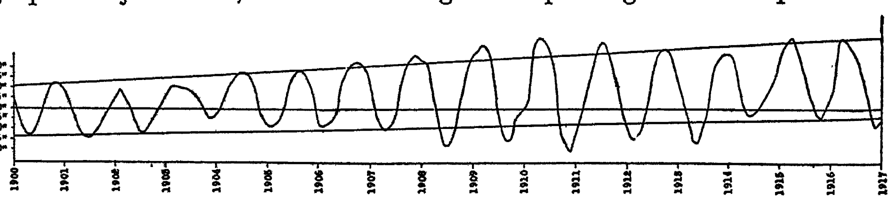

Fig. 1. The latitude of Ukiah, California, from Dyson's curves, with lines drawn by Lawson to show the progressive increase of latitude.

to the maxima of the curve and a similar line for the minima, and then drew a line bisecting the angle between the two lines just found. This bisector may be taken as representing the true zero line.

The slope of this true zero line referred to the conventional one is, as found by Professor Lawson, 0".0094 or 0.29 meter a year. His method does not use all the information afforded by the curve, but merely the maxima and minima; the lines drawn to fit these are necessarily affected by personal idiosyncrasies. The following method is free from these objections.

The curve supposedly contains only the effect of the 14-month component and of a possible progressive shifting of the zero line. The former effect will be eliminated from the mean of 14 successive calendar months,[5] leaving in the mean only the progressive shift

[5] The exact period is 432.5 days rather than 14 calendar months (426 days), but the error arising from the substitution of one period for the other is negligible.

of the zero. Table 1 shows the result of taking these means. They are also shown graphically in figure 2.

Instead of adjusting a straight line to the means by eye we may do it by the method of least squares. The observation equations would then be written in the form

$$\Delta\phi = x + yt,$$

TABLE 1.—MEAN VALUE OF $\Delta\phi$ FOR UKIAH

Middle of 14-month period	Mean $\Delta\phi$	Middle of 14-month period	Mean $\Delta\phi$
1900, Aug. 1	+0″.001	1908, Oct. 1	+0″.047
1901, Oct. 1	−0 .040	1909, Dec. 1	+0 .058
1902, Dec. 1	+0 .001	1911, Feb. 1	+0 .070
1904, Feb. 1	+0 .047	1912, Apr. 1	+0 .063
1905, Apr. 1	+0 .054	1913, Jun. 1	+0 .055
1906, Jun. 1	+0 .068	1914, Aug. 1	+0 .118
1907, Aug. 1	+0 .066	1915, Oct. 1	+0 .152

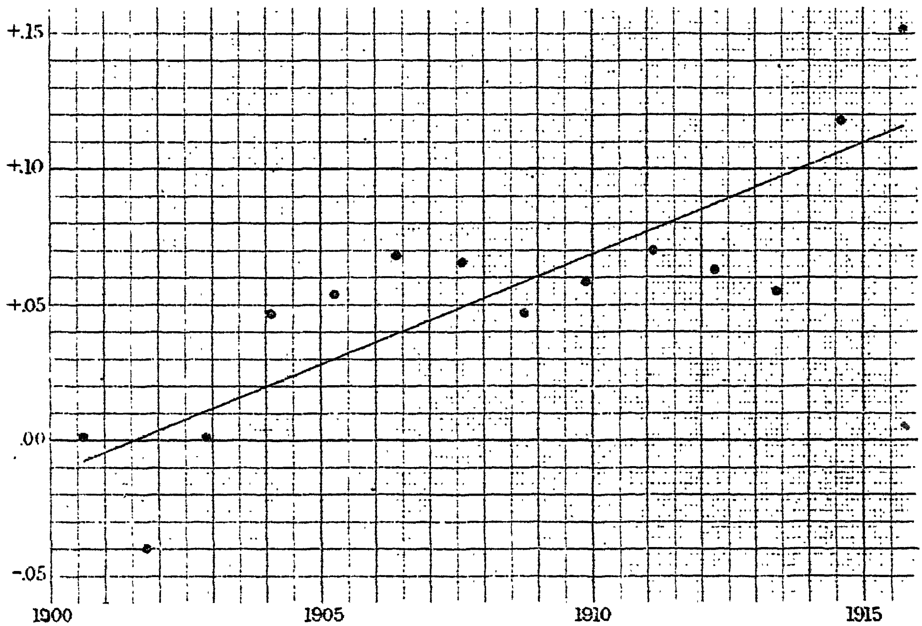

Fig. 2. The latitude of Ukiah, California, means by 14-month periods and line showing adjusted rate of increase; derived from Dyson's curves.

where t is the time reckoned from some convenient epoch, x is the adjusted value of $\Delta\phi$ at the epoch, y is the adjusted rate of change of the mean latitude, and the $\Delta\phi$ represents one of the values of $\Delta\phi$ in the table. The result of the adjustment gives for the equation of the

true zero line

$$\Delta\phi = +0''.0590 + 0''.0081t,$$

where t is the time in years reckoned from the epoch, Oct. 1, 1908. This line is the one shown in figure 2. The slope $+0''.0081$, with a probable error $\pm 0''.0010$ per year, is somewhat smaller than the $+0''.0094$ found by Professor Lawson but still quite large enough to be of interest, and if taken at its face value, it is large enough to render probable Professor Lawson's thesis of a northward movement of the superficial crust at Ukiah.

Before reaching definite conclusions in the matter it is desirable to see what is happening at the other stations of the International Latitude Service. These stations all use the same program of stars and any errors in the declinations used affect all stations alike except insofar as bad weather may cause the stars observed to be different at the different stations. It is to be supposed, however, that the difference in the effect at different stations of errors in declination due to the different stars actually used may be considered as causing accidental errors in the result rather than systematic ones. The observatories of the Latitude Service are all close to the parallel[6] of 39° 8′; they are: Mizusawa in Japan, still running; Tschardjui (or as more simply spelled Charjui) in Russian Turkestan, closed at the end of 1914; Carloforte on a little island off the larger island of Sardinia, still running; Gaithersburg, Maryland, closed at the end of 1914; Cincinnati, Ohio, work for the International Latitude Service discontinued at the end of 1915; Ukiah, California, still running.

It was the original intention to have all the observatories constructed on exactly the same plan and equipped with zenith telescopes of the same pattern. It proved impracticable, however, to live up to this plan and the instruments at Tschardjui and Cincinnati are smaller than those at the other stations. This fact and perhaps also the vagaries of their climates, which are more markedly continental in character at these stations than at the other four, have caused the probable errors of the results from Cincinnati and Tschardjui to be relatively large. Furthermore, the Tschardjui results are complicated by the removal of the observatory in 1909 to a new location, a removal forced by the wanderings of the Amu Darya River, the ancient Oxus. The old site was threatened and finally inundated and the latitude connection between the old and new sites is rather weak. All these

[6] For longitudes see table 2 on p. 36

circumstances combined have made the results at Tschardjui relatively so inaccurate that they have very little weight in the final results of this discussion. To a less degree the same holds good of Cincinnati. The observations at the four remaining stations are about equal in quality.

Sir Frank Dyson did not give curves like that at Ukiah for all the six stations and there appeared to be some uncertainty about the declinations used in the latter part of the period that he treats, a matter important for the present purpose but not very important for his purpose, so it was decided to start afresh and to derive curves for all six stations, utilizing all the observed latitudes available; these extended from 1900 through 1917, a year beyond the time covered by Dyson. The new curves were based on the definitive latitudes of the International Latitude Service[7] and the provisional results published from time to time in the *Astronomische Nachrichten.*[8] These results are all on a common declination system, that of Vol. 3 of the *Resultate,* not the ideal system perhaps, but one consistent with itself. On account of the precession some of the stars necessarily drop out of a star program as time goes on. In the provisional results these discontinued stars have not been replaced by others. The provisional results therefore depend on a smaller number of stars, thus reducing the weight of the results to about $^5/_6$ of that of the definitive ones.

The latitudes of the several stations were plotted, curves were drawn to smooth out the worst roughnesses in the plotted values, and these curves were analyzed harmonically to obtain the amplitudes and epochs of both the annual and the 14-month components. Each station was treated by itself. Some refinements not found in all harmonic analyses were introduced and seemed to justify their introduction by the better agreement thus obtained between the various determinations of the same quantity. The details will be given in my longer publication on the subject.

By taking out the annual term from the curve of observed latitudes it would have been possible to draw curves like Dyson's, containing, presumably, only the effects of the 14-month term and of a possible shift in the true zero line. At least, if other effects were present, they would be treated as accidental errors. By reading these new

[7] Zentralbureau der Internationalen Erdmessung (Berlin). *Resultate des Internationalen Breitendienstes.* **3:** 1909. **5:** 1916.

[8] Astr. Nachr. **198:** No. 4749. 1914. **201:** No. 4802. 1915. **203:** No. 4855. 1916. **206:** No. 4908. 1917. **208:** No. 4969. 1918.

curves at uniform intervals and taking the mean of the readings over a period of 14 months, the effect of the 14-month term would be made to

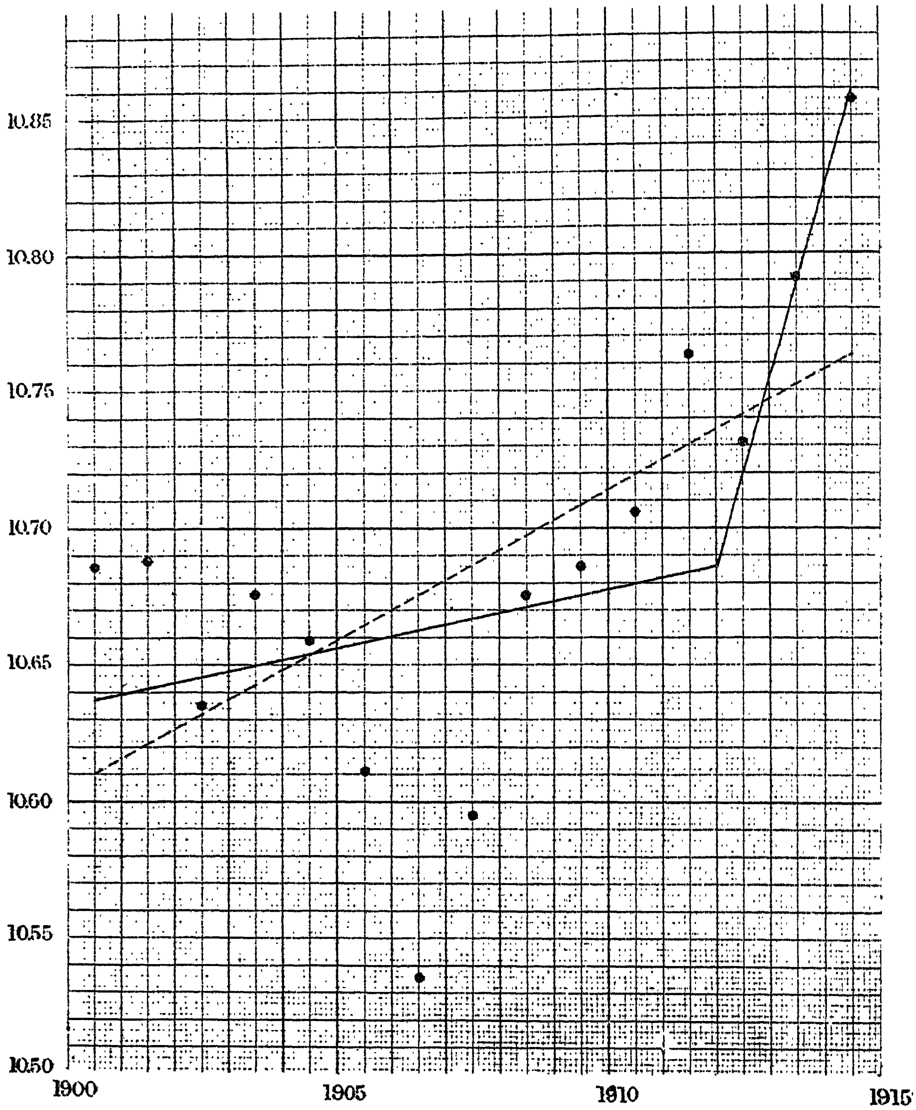

Fig. 3. The latitude of Tschardjui, Russian Turkestan: means by calendar years and lines showing adjusted rates of change; derived from the latitudes of the International Latitude Service.

disappear from the mean, leaving only the effects of a shifting of the zero line, that is, of a progressive change in the mean latitude.

It would be equally legitimate to interchange the processes by which the two periodic portions of the latitude variation were eliminated. Instead of taking out the effect of the annual portion by computing from an assumed expression for it in the form of an harmonic term, we could take out the 14-month component by assuming it to be expressed by a harmonic term and computing the necessary values. The remaining periodic portion of the variation would be the annual portion and could be eliminated by taking means over the period of a year. These means, being free from the effects of periodic terms, should bring to light the progressive variation.

Both methods were employed and the two rates thus obtained for the progressive change of latitude at a station agreed well in all cases. There appeared to be some reason for thinking that the rate of change might be different for the later years; with this in mind the experiment

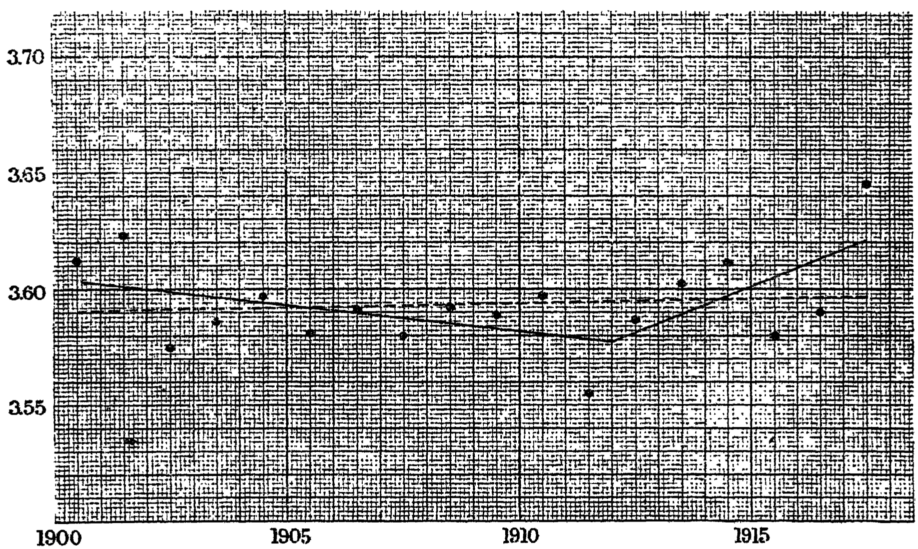

Fig. 4. The latitude of Mizusawa, Japan; means by calendar years and lines showing adjusted rates of change; derived from the latitudes of the International Latitude Service.

was tried of fitting two straight lines to the mean latitudes instead of only a single line, the two lines to show the same latitude at a predetermined epoch. This epoch was taken not far from the end of 1911. The considerations governing this choice were in part the general appearance of the plotted mean latitudes and in part the change in the star program at the end of 1911 already referred to and due to the dropping of certain stars.

The closeness of the fit of the two lines or of the single lines may be judged from figures 3 and 4. Figure 3 shows the results for Tschardjui, the means being taken by calendar years. It has been said that this station has been subject to great irregularities and this appears plainly from the diagram. The only thing that clearly appears is a tendency for latitudes to increase very sharply towards the end of the period. Figure 4 shows Mizusawa, perhaps the most regular station, though the other stations except Tschardjui and Cincinnati are not greatly inferior to it. Even the most regular of stations shows considerable departure from a perfectly uniform progressive increase, although the irregularity is somewhat exaggerated to the eye by the large vertical scale used for the latitudes. The probable error of the mean of a single year or of a single 14-month period is about $\pm 0''.010$ at Mizusawa as determined from the residuals arising from attempting to fit the two straight lines to the successive means. The probable error is rather larger when only a single line is used, a fact which tends to prove the reality of the assumed change in rate. Similar results hold for the other stations except Tschardjui and Cincinnati, the probable errors being about $\pm 0''.015$ for the two lines and about $\pm 0''.018$ for one line.

The mean rates of increase are shown in table 2. They represent the mean results of the two methods of procedure already referred to, mean latitudes being taken by calendar years and by 14-month periods. The fitting of the straight lines to the means was done by the method of least squares.

TABLE 2.—MEAN ANNUAL RATES OF CHANGE OF LATITUDE

Station	Longitude	Observations end with year	Annual rates of change 1900–11	1912–end	1900–end
Mizusawa, Japan..........	141° 08′ E	..	$-0''.0025$	$+0''.0096$	$+0''.0008$
Tschardjui, Russian Turkestan....................	63 29 E	1914	$+0''.0036$	$+0''.0597$	$+0''.0115$
Carloforte, Sardinia........	8 19 E	..	+0 .0002	+0 .0182	+0 .0053
Gaithersburg, Maryland....	77 12 W	1914	+0 .0087	+0 .0206	+0 .0105
Cincinnati, Ohio..........	84 25 W	1915	+0 .0029	+0 .0404	+0 .0099
Ukiah, California..........	123 13 W	..	+0 .0075	+0 .0194	+0 .0106

The first two columns under the general heading "Annual rates of change" give the slopes or rates of change of latitude when two lines are used. The last column gives the slope when only one line is used. The rate of change may vary with the period of time covered so that only in the first column are the rates for all stations strictly comparable with one another. In the second and third columns the rates of Mizusawa, Carloforte, and Ukiah are comparable in this way. The

rates in the second column, particularly the rates of stations now discontinued, depend on only a few mean latitudes, and offer only an insecure basis for conclusions.

The rates of change at Ukiah are not very different from the rates found from Dyson's curves, namely, $+0''.0094$ by Lawson and $+0''.0081$ by the author.[9] The striking fact, however, is that a rate of this size is no longer a solitary phenomenon. There are many rates of this order of magnitude and with one exception all rates are positive.

Before seeking an explanation I think it will be wise to rule out the results for Tschardjui altogether. If results were weighted according to their probable errors, the Tschardjui results would get weights only from 1/10 to 1/20 as large as those of other stations, and would thus have little effect on our final conclusions.

We might explain the positive rates at all stations by a northward creep of the surface strata, as Professor Lawson has done for Ukiah, but such an explanation is scarcely satisfactory when it must be made to apply to so many stations. A better partial explanation is *declinations*. The so-called observed latitudes are also computed ones to a certain extent, and errors in the declinations of the stars used appear with practically full effect in the so-called observed latitudes. It would appear from the table as if the average declinations became increasingly erroneous with the lapse of time; an error of this kind would naturally be looked for in the adopted values of the proper motions. But even an error in the proper motions and the consequent declinations does not explain all the rates in the table. An error in the star places would affect all stations alike, except insofar as bad weather might cause the stars actually observed to vary from station to station. It is clear that latitudes are increasing much faster on the American continent than elsewhere, and for a while in the opposite quarter of the world, as at Mizusawa from 1900 to 1911, they were actually decreasing. An obvious explanation of an increase in latitude on one side of the earth accompanied by a decrease in the other is a shifting of the Pole.

I believe that the explanation of the changes of latitude set forth in the table will be found in a shifting of the Pole combined with an increasing error in the declinations. This hypothesis may be tested by a least-square adjustment. Let u and v denote the components

[9] The number in the table most nearly corresponding to the result for Ukiah found from Dyson's curves is the $+0''.0106$ in the last column. The difference is probably due in great part to the declination system used. See below.

of the assumed annual shift of the North Pole towards the Equator along the meridians of Greenwich and of 90° W, respectively; let w denote the annual increase in latitude common to all stations and due to erroneous declinations; then the observation equations have the form

$$u \cos \lambda + v \sin \lambda + w = \text{observed annual rate,}$$

where λ is the west longitude of the station in question.

Various least-square solutions were tried with different weights for the several stations and different sets of annual rates. Full details will be given in the longer publication. The results were fairly consistent and the adopted result was a motion of the North Pole southward along the meridian of 77° West of Greenwich at a rate of about 0″.0050 a year. The values of w depend on the star program and represent mean cumulative corrections to the declinations for the period covered; they might therefore be expected to differ according to the set of rates used, even if the components of the polar motion remained constant. This was found to be the case, the values of w ranging from +0″.0013 to +0″.0050.

This then is the interpretation I would offer of the apparent increase in latitude at Ukiah; cumulative errors in the declinations combined with a shifting of the North Pole towards the American continent. There might be also the surface creep which Professor Lawson offers as the all-sufficient explanation, but I believe that if this creep exists, its contribution to the increase in latitude is quite subordinate to the contributions of the other causes.

The suggestion of a displacement of the Pole towards the American continent has been made before. Wanach,[10] the successor to Albrecht in the work of the International Latitude Service, found from the observations of the Service from 1900 to 1911, inclusive, a displacement of the North Pole at the rate of not more than 0″.0030 a year and in the general direction of Newfoundland, say along the meridian of 56° West. The period of time covered is different, likewise the method of treatment and the weights assigned to Tschardjui and Cincinnati. The differences doubtless explain the differences in the results, differences not particularly large in view of the difficulties of the subject.

It is evident that the burden of proof for this explanation of the change of latitude at Ukiah by a shifting of the Pole rests chiefly on the results at Gaithersburg, for Ukiah is suspected of being on unstable

[10] B. Wanach. *Resultate des Internationalen Breitendienstes* 5: 219. 1916.

ground and Cincinnati is subject to a large probable error. A little consideration will show, however, that an explanation of the kind supposed that is numerically adapted to fit Gaithersburg as well as the other stations except Ukiah must be a passable fit for Ukiah also.

The deduced shifting of the Pole must be considered as limited to the period discussed, the years 1900–1917, inclusive. No examination has been made of earlier records to see whether such a shifting might have taken place in the past, and until the causes of such a shifting have been found it is unwise to predict the future. In regard to the past, it is interesting to note that a polar shifting of this sort and about this magnitude might have gone on during the whole historical period without changing the climate perceptibly. If we put the historical period at 10,000 years in round numbers, the maximum change of latitude during that time is less than a mile. It might perhaps be possible for a change of this particular sort, namely along the meridian of 77° West, to have gone on since the beginning of modern astronomy of precision—say since Bessel's time—without being noticed, simply because the longest series of accurate records are in central or western Europe, regions which are on meridians nearly at right angles to the line of displacement and which therefore undergo a relatively small change of latitude.

It is of interest to consider the possible causes for such a displacement of the Pole. A little calculation shows that the shifting of mass due to erosion and deposition of all sorts, even on the most favorable hypotheses, is quite insufficient to produce a shifting of $0''.0050$ a year in the direction of the earth's axis within its mass. Theories postulating large departures of the Pole from its present position have been much in favor with certain geologists but seem fantastic to mathematicians and astronomers. An interesting criticism of these theories is to be found in an article by the late Professor Barrell.[11] The classic paper on this subject from the mathematical point of view is by Darwin.[12] A shifting of the Pole may be brought about by widespread though slight elevations and subsidences of the Earth's crust. On the most favorable assumption that seemed in any way plausible from a geological point of view, Darwin found a possible displacement of from 1° to 3° in any one geological period. The term "geological period" is conveniently vague as a unit of time, but if we take a geolog-

[11] J. BARRELL. *The status of the hypothesis of polar wanderings.* Science **40**: 333. 1914.

[12] G. H. DARWIN. *On the influence of geological changes on the Earth's axis of rotation.* Phil. Trans. Roy. Soc. Lond. I. **167**: 271. 1877. Or *Scientific Papers* **3**: 1.

ical period as meaning a million years,[13] which corresponds to one estimate of the duration of the entire glacial epoch, including all the various periods of glaciation and the interglacial periods between them, then a shift of 0″.0050 a year would mean a change of 1° 23′ in the position of the Poles during the glacial epoch, a quantity within Darwin's limits.

Now the fact that the shifting of the North Pole towards the American continent appears to have continued for the 18 years from 1900 to 1917, inclusive, does not oblige us to suppose that it has continued in the past or will continue in the future. Indeed, very recent observations at Ukiah would indicate, if taken at their face value, that the mean latitude of Ukiah is decreasing, that is, that the Pole is moving back again. No satisfactory conclusions can be reached, however, until the observations at the other latitude stations become available. There is some evidence of certain periodic effects in the variation of latitude other than those represented by the annual and the 14-month terms, effects whose periods are three years or more and which may be connected with the periods of the still obscure meteorological and climatic cycles. The shifting of the Pole may represent chiefly the combined effect of meteorological causes running their courses in periods of a few years or a few decades and be due only in very small part to elevations or subsidences of the crust.

Some of the by-products of the investigation may now be mentioned. The calculations necessary to derive the foregoing conclusions were quite extensive and made it possible to obtain with but little additional labor other results of interest in connection with the general problem of the variation of latitude. Fuller details will be given in the larger publication already referred to.

An examination was made with a view to detecting terms in the variation with periods of three and six years. Terms of these periods in the distribution of barometric pressure over the earth were found by Angenheister;[14] the magnitudes of the fluctuations of pressure appeared to be probably sufficient to affect the motion of the Pole perceptibly. Harmonic constants were deduced from the observations

[13] Cited by M. P. RUDZKI in his *Physik der Erde* (Leipzig, 1911), p. 552, as the estimate of PENCK and BRÜCKNER for the duration of the glacial epoch.

[14] G. ANGENHEISTER. *Über die dreijährige Luftdruckschwankung und ihren Zusammenhang mit Polschwankungen.* Nachr. kön. Ges. Wiss. Göttingen, Math-phys. Kl. **1914**: 1. The paper is described as a preliminary communication but nothing further from Angenheister on the subject has come to the author's attention.

for terms of these periods, but the amplitudes and epochs thus found differed considerably according to stations used and the period of time covered by the observations. Probably there are perceptible terms of this sort, but the mathematical expressions for them are still quite uncertain.

Expressions in harmonic form were found for the annual portion of the polar motion and of the Kimura term. For corresponding periods of time these expressions were in excellent agreement with similar expressions deduced by the International Latitude Service, although the methods of deduction were quite different.

Similar expressions in harmonic form were found for the 14-month portion of the motion of the Pole. In deducing these terms the motion of the pole of rotation was not assumed to be uniform and circular, as it would be if changes in position of the pole of figure were strictly periodic and if the two principal equatorial moments of inertia of the Earth were equal. If, however, the assumption of uniform circular motion is made in this discussion, as it is in the work of the International Latitude Service, the expressions for the 14-month motion of the Pole agree well with the corresponding ones deduced by the Latitude Service, in spite of the difference in methods. Without the assumption of circular motion the observations always give an elliptical 14-month path for the Pole, but one so nearly circular that the exact direction of its major axis is not very certain. The major axis should coincide in direction with the meridian of the larger principal equatorial moment of inertia[15] if there is any perceptible difference in the principal equatorial moments, and it is for this reason that it is of interest to determine the position of the major axis of the ellipse of polar motion. Wanach of the International Service speaks discouragingly of the results obtained,[16] but in the present investigation the results for different six-year periods show a fair degree of agreement, perhaps

[15] This statement is subject to a correction for the effect of the yielding of the ocean waters to the forces arising from a change in position of the Pole. If the ocean covered the Earth, its yielding would prolong the period of the latitude variation as compared with that of an otherwise similar earth without an ocean, but the position of the major axis of the ellipse of polar motion would be the same for both earths. On account of the unsymmetrical distribution of land and water on the actual Earth the position of the axis of the ellipse of polar motion is affected, but the amount of the correction appears not to be sufficient to change the general character of the observed results. The subject has been investigated by A. BRILL in his doctor's thesis entitled *Über die Elastizität der Erde* (Göttingen, 1908). His conclusions do not appear to be in a form immediately applicable to the problem in hand. The question is being further investigated.

[16] *Resultate des Internationalen Breitendienstes*, 5: 220, footnote.

on account of the refinements in harmonic analysis already referred to. In table 3 λ is the west longitude of the meridian along which the major axis lies.

TABLE 3.—DIRECTION OF THE MAJOR AXIS OF THE ELLIPSE OF POLAR MOTION (432.5 DAY PERIOD)

Years, inclusive	Number of stations	Direction of major axis λ
1900–05	6	59° W
1906–11	6	90 W
1912–17	3	117 W
1910–15	4	75 W
1900–11	6	81 W
1900–17	3	110 W

The first three lines give results for each of the three six-year periods[17] into which the time covered by the observations is divided. The fourth line represents a series cutting across two other series and serves as a check. Other check results, not given here, were obtained and were all to the same general effect. The last two lines are mean results for the periods specified. A mean for the result of the entire discussion might be taken, somewhat arbitrarily perhaps, as 90° West. Helmert[18] has determined the same quantity from gravity observations, his result being 107° West. Since gravity can at present be observed satisfactorily only on land, that is, on one-fourth only of the Earth's surface, and since the influence on gravity of local topographic and geologic conditions is considerable, it is satisfactory to have even a rough agreement of the results from the two methods.

The amount of the difference between the principal equatorial moments, A and B, may be specified by giving the ratio

$$(B-A) \div [C-\tfrac{1}{2}(A+B)],$$

the letter C denoting the moment of inertia about the axis of rotation. Helmert finds for this ratio 1/46. The same ratio may be deduced from the eccentricity of the ellipse of polar motion; the results of this investigation point to a value of the same order of magnitude but apparently somewhat larger, perhaps 1/30 or 1/20, ratios which would follow from some of the gravity formulas which Helmert derives only to reject in favor of the formula leading to 1/46. From the ratio $(B-A \div [C-\tfrac{1}{2}(A+B)]$ we may deduce the difference between the greatest equatorial radius of the Earth and the least. For Helmert's ratio 1/46 this difference is 230 meters; for larger or smaller ratios the difference between the equatorial radii varies proportionally.

[17] The six-year length of series is particularly suitable for harmonic analysis.

[18] F. R. HELMERT. *Neue Formeln für den Verlauf der Schwerkraft im Meeresniveau beim Festlande.* Sitz.-Ber. kön. preuss. Akad. Wiss. 1915: 676.

Since this ratio, like the direction of the major axis, is subject to a correction for the yielding of the ocean waters under the centrifugal force arising from the variation of latitude itself, no precise results are stated in this connection as the definitive results of the investigation until this correction can be investigated and applied. The important points are (1) that, contrary to Wanach's implied opinion, there is some prospect of getting information regarding the moments of inertia and the figure of the Earth out of the observations of the variation of latitude; and (2) that the results so far obtained confirm in a general way the results of Helmert from gravity observations.

The principal results of this investigation may be summed up as the prospect just mentioned of getting data on the figure of the Earth out of the latitude observations, and the conclusion previously discussed that the increase in latitude at Ukiah is due partly to the declinations used, being to that extent unreal, and partly due to a shifting of the North Pole towards the American continent.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts preferably prepared, and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to these appearing in this issue.

OCEANOGRAPHY.—*Tidal observations off the entrance to Delaware Bay.* H. A. MARMER. Journ. Franklin Inst. **191**: 819–821. 1921.

This paper discusses the results of a forty-hour series of offshore tidal observations made on Five Fathom Bank, about 18 nautical miles off the entrance to Delaware Bay, by a hydrographic party of the Coast and Geodetic Survey. Special interest attaches to this series of observations, because of its being made at some distance from the coast and also because of the simple and inexpensive tide gauge used. At present our knowledge of the time and range of the tide away from the coast is extremely meager, since tidal observations have been confined almost wholly to the immediate vicinity of the coast.

A description of the tide gauge inprovised for observing the height of the tide is described and the results compared with simultaneous tidal observations at Breakwater Harbor, Delaware, about 23 miles west of Five Fathom Bank. The cotidal hour as determined from these observations agrees well with the cotidal lines for this region constructed by Harris from theoretical considerations. H. A. M.

ORNITHOLOGY.—*Washington region [February and March, 1920].* H. C. OBERHOLSER. Bird Lore **22**: 167. 1920.

Notwithstanding a backward spring, birds appeared about Washington in about their usual numbers and at about their usual time during February and March, 1920. The European Starling (*Sturnus vulgaris vulgaris*) has become thoroughly established in the vicinity of Washington. Without

doubt the outstanding feature of interest was the astonishing number of ducks that frequented the Potomac River. The species most abundant were *Marila marila*, *Marila affinis*, *Anas rubripes*, and *Glaucionetta clangula americana*. Flocks of geese, *Branta canadensis canadensis*, and swans, *Olor columbianus*, were also present. H. C. O.

ORNITHOLOGY.—*Birds of the Clear Creek District, Colorado.* F. C. Lincoln. Auk **37**: 607. 1920.

Systematic investigations in the region about Clear Creek near Denver, Colorado, during a period of five years have resulted in a list of 182 birds, including a number of rare species. H. C. Oberholser.

ORNITHOLOGY.—*Relative abundance of wild ducks at Delavan, Wisconsin.* N. Hollister. Auk **37**: 367–371. 1920.

Records of ducks obtained at Delavan, Wisconsin, during the years 1892 to 1899 give an interesting indication of the relative abundance of species during that period. A list is given showing the species observed in the order of their abundance. H. C. Oberholser.

ORNITHOLOGY.—*Four new birds from the Philippines and Greater Sunda Islands.* J. H. Riley. Proc. Biol. Soc. Wash. **33**: 55–58. 1920.

The following subspecies of East Indian birds are described: *Anthreptes malacensis paraguae*, from Palawan, Philippine Islands, *A. m. bornensis*, from British North Borneo; *Enodes erythrophrys centralis*, from Celebes; and *Munia punctulata particeps*, from Celebes. H. C. Oberholser.

GEOLOGY.—*Oil prospects in Washington County, Utah.* Harvey Bassler and John B. Reeside, Jr. U. S. Geol. Surv. Bull. **726**-C. Pp. 87–107. 1921.

Washington County, in extreme southwestern Utah, is drained by Virgin River, one of the larger tributaries of the Colorado. Exploratory drilling for oil has not been extensive in Washington County. Drilling near Virgin City resulted in several small wells as early as 1907.

The rocks of the region range in age from Mississippian to Tertiary, but those of greatest importance as possible sources of oil are the older rocks, beneath what is known as the Shinarump conglomerate. These older rocks are included in the Moenkopi formation, the Kaibab limestone, and a sandstone formation which represents the Coconino sandstone and Supai formation of the Grand Canyon area.

The region may be considered structurally as two districts separated by the Hurricane fault, which runs north and south on a line 15 miles east of St. George. East of the fault the rocks are relatively little disturbed. Some smaller faults and some low anticlines are present, but as a whole the district is one of low monoclinal dips without any large modifications. West of the Hurricane fault folds and smaller faults of various sizes have so greatly changed the original attitude of the rocks that the district is structurally complex in comparison with that east of the fault.

Nothing more was done in the field near Virgin City east of the Hurricane fault until 1918, when the three producing wells were cleaned out and shot, pumping was started, and a small local refinery was built. A new well was drilled near the old wells and has a production of 4 or 5 barrels a day. The total production from the four wells, which are uncased holes 550 to 600 feet

deep, is about 20 barrels a day (September, 1920). The bulk of this amount is coming from one well, the other wells pumping much more water than oil. The refinery will handle 800 gallons of crude oil per 8-hour shift, and the products find a ready local market.

The oil is reported to range in gravity from 25° to 35° Baumé, to have a paraffin base that includes some asphalt, and to contain some sulphur. The oil comes from a 1-foot bed of limestone which is at the top of the basal Rock Canyon conglomeratic member of the Moenkopi.

It seems most probable on the evidence presented that terraces, or areas of low dip, are favorable to the accumulation oil in this field and that the steep slopes are unfavorable. There are no anticlines, faults, or other features closely enough associated with the producing field to offer an explanation for the accumulation of oil, so that the only likely factor left is that of accumulation on a terrace.

The value of the region west of Hurricane fault as a possible producer of oil it is impossible, of course, to gage in advance of drilling. The region near St. George contains favorable structural features, and there are rocks in them capable of serving as reservoirs for oil. At certain places, there is evidence favorable to the assumption that these rocks carry some oil. Whether oil is actually present in these rocks in the anticlines and domes remains for the drill to determine.

The report closes with recommendations for drilling. H. W. STONE.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

The 152nd regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club at 8 p.m., Tuesday, May 3, 1921. There were 32 present.

The meeting was called to order by President CHAMBLISS, after which the minutes of the last meeting were read and approved. The executive committee presented the names of Mr. A. J. BRUMAN, Mr. FRANK G. O'DONNELL and ROBERT CLAUDE WRIGHT as candidates for membership.

Dr. ROBERT F. GRIGGS of the National Geographic Society, MR. CHARLES G. WOODBURY, Director of the Bureau of Raw Products Research, National Canners' Association, and Mr. JOHN W. TAYLOR of the Office of Cereal Investigations of the Bureau of Plant Industry, whose names were presented at the April Meeting, were voted into the Society.

A letter from the Commission of Fine Arts to the Society in regard to the establishment of a National Botanic Garden on the Mount Hamilton tract was read.

Mr. PICTER moved that the Chair appoint a committee to represent the Society in furthering the Botanic Garden project. This was seconded, the motion put and carried. President CHAMBLISS later appointed on this committee the following:

Mr. DAVID G. FAIRCHILD, *Chairman*
Prof. L. G. CORBETT
Mr. F. V. COVILLE
Mr. WALTER T. SWINGLE
Mr. GEORGE B. SUDWORTH

The regular program of the evening followed:

PETER BISSET: *Roses for Garden Decoration* (illustrated).

The conditions suitable for best results in growing roses may be summarized. The location should be open to the sun from the East and South and protected from the West and North by trees, preferably evergreens. The soil must be well drained and should be enriched by the application of well-rotted manure, which should be thoroughly spaded in. Four pounds of bone meal should be added to each wheelbarrow load of soil.

Concerning varieties; the tea roses are very popular. The hybrid tea is probably the rose of the future for American gardens. Maman Cochet, a hardy tea rose, is well adapted to the climate of Washington. Of the hybrid perpetuals, Baroness de Rotheschild, Mrs. John Laing, Mad Gabriel Luzett, Ulrich Brunner, Paul Neyron and Frau Karl Druschke are among the most beautiful. The ramblers have their use and can transform an ugly fence or unsightly place into an attractive picture. Among the Rugosas, which come to us from China, the most attractive are Mrs. George Bruant, Blanch double de Coubert, with its semi-double flowers, and Alba semi-plenary and the hybrid Conrad F. Meyer. Hugonis is one of the latest arrivals—a new yellow rose.

Twenty-four varieties of roses are recommended for general garden culture:

Augustine Guinoisseau	Mme. Abel Chatenay
Caroline Testout	Mme. Hoste
Cecile Brunner	Mme. Jean Dupuy
Dean Hole	Maman Cochet
Fabvier	Marie van Houtte
Fisher Holmes	Mrs. John Laing
Florence Pemberton	Mrs. R. G. Sharmon-Crawford
Frau Karl Druschki	Rosette de la Legion d'Honneur
Gustave Grunerwald	Souvenir du President Carnot
Gustave Regis	Ulrich Brunner
Kaiserin Augusta Victoria	Victor Hugo
La France	White Maman Cochet

Dr. C. DWIGHT MARSH: *Poisonous Whorled Milkweeds* (illustrated).

Asclepias galioides, the whorled milkweed, is one of the most poisonous plants which has been investigated. This species is confined to Arizona, New Mexico, Colorado and Utah. Two to three ounces of a fresh plant of *A. galioides* will kill a sheep. The effects from eating are violent spasms, then death. High temperatures are reached in some animals in acute stages. This species is equally poisonous to sheep and horses but is not so poisonous to cattle, that is, with equal doses per hundred weight.

There are at least two toxic substances in plants: (1) a narcotic glucoside, (2) a spasmodic principle. These have been separated. Capillary congestion is caused in the organs of the animal, also degeneration in the organs. This is so serious that recovery rarely occurs.

Asclepias pumila is found on the plains in Eastern Colorado. Eating of these plants caused same symptoms in the animal as *A. galioides*, but the plant is not so toxic. The dosage is 4 times as great.

A. verticillata geyeri—Missouri Valley, Iowa. Animals eating this plant show same symptoms, but plant is still less toxic. Dosage 10 times as much. It is of little importance as a poisonous plant. Dosage 2 pounds per 100 lbs. plants.

A. mexicana is found in Nevada and California extending south into Mexico. Same symptoms—not as toxic about like pumila—dosage 4 times *galioides.*

All produce same effect on animals. *Galioides*—a dry land plant—spreads by seed and by roots—cultivation spreads plant.

Dr. ARNO VIEHOEVER: *Edible and Poisonous Beans of the Lima Type.—Phaseolus lunatus L.* (illustrated).

Beans of the lima type (*Phaseolus lunatus*) are rich in food essentials, carbohydrates, protein and fat. All varieties contain, in addition, the glucoside linamarin, yielding, like the amygdalin of bitter almonds, hydrocyanic acid when macerated with water. In domestic cultivated forms the amount of hydrocyanic acid is so small that the beans can be considered safe for consumption. The majority of samples obtained from tropical countries, however, were found to yield excessive amounts of the poisonous acid in different samples as well as in individual beans of the same sample. The amount of hydrocyanic acid found in the domestic lima beans ranged from a trace to the maximum of 10 mg. per 100 g. of beans. We obtained from the tropical beans quantities of hydrocyanic acid amounting to as much as 300 mg. and more in 100 g. of the material.

The large, uniformly white lima bean, grown on an extensive scale in California, and also imported from Madagascar, has been found harmless. Small lima beans cannot be considered as coming from a different species than the large lima beans. The most poisonous forms found were, however, beans of the small type.

The color does not differentiate the harmless from the poisonous forms, neither do the morphology or structure of the beans give safe means of separation and differentiation. There are, however, morphological and anatomical characteristics which permit the ready differentiation of beans of the lima type from beans of other types, one of the most striking means being the general absence of calcium oxalate in the seedcoat of *Phaseolus lunatus.*

Cooking of the poisonous beans does not render them harmless, although the boiling water will extract a portion of the compound yielding hydrocyanic acid.

The name "Lima Bean" should be limited to the edible forms.

ROY G. PIERCE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Forty-one Federal Government periodicals suspended publication on December 1, for lack of specific authorization from Congress for their continuance. Among the scientific and technical periodicals suspended are: *Experiment Station Record; Journal of Agricultural Research; Monthly Weather Review;* and *Public Roads.*

The Petrologists' Club met at the home of H. G. FERGUSON on December 20, and discussed the following topics: E. B. SAMPSON: *Origin of serpentine in the lime type of asbestos deposits;* S. H. CATHCART: *Review of W. N. Benson's "Origin of serpentine;"* C. S. ROSS and E. V. SHANNON: *Iddingsite as a deuteric mineral.*

The National Museum reports the receipt of a fragment of a heretofore unknown meteorite (a pallasite) from Cold Bay, western Alaska. The entire mass as found was in the form of a badly oxidized mass of but a few pounds weight, which was at once broken up by the finders and in large part lost. The find is the second from Alaska proper, the first having been that of Chilkat (an iron).

The Bureau of Standards announces that a considerable improvement has been noted in the quality of American analytical weights. A number of sets have been received recently in which every weight was within the prescribed tolerances, while four recent sets of foreign weights showed 20 to 32 per cent of the weights outside the tolerances.

A dinner was given at the Cosmos Club on Friday night, December 16, by the officers of the ACADEMY and the Chemical Society in honor of Prof. JACQUES CAVALIER, recteur of the University of Toulouse and Exchange Professor at a group of American universities. The dinner followed a lecture by Prof. Cavalier at the Bureau of Standards in the afternoon, on *Les industries chimiques en France pendant la Guerre*.

Dr. BARTON W. EVERMANN, at one time with the U. S. Fish Commission in Washington, and a former editor of the *Proceedings* and of the *Journal* of the ACADEMY, has been appointed director of the new Steinhart Aquarium of the California Academy of Sciences at San Francisco, California.

A course of ten lectures on applied anthropology is being given by Dr. ALES HRDLICKA, of the National Museum, under the joint auspices of the Educational Department of the Young Men's Christian Association and the Institute of Vocational Research of Washington.

Dr. W. J. HUMPHREYS of the Weather Bureau lectured before the Physics Club of the Bureau of Standards on November 28, on *The temperature and other conditions of the free air*.

Dr. FRANZ AUGUST RICHARD JUNG, a practicing physician in Washington, and a resident member of the ACADEMY since 1902, died at his home at 1868 Columbia Road on December 16, 1921, in his fifty-third year. Dr. Jung was born in Thuringia, Germany, October 9, 1869. He came to the United States in 1896, and took up the practice of his profession in Washington in collaboration with his wife, Dr. SOFIE A. NORDHOFF-JUNG. They were in Munich when the War began in 1914, and opened there an American Red Cross Hospital, which was closed in 1917 when the United States entered the War. Dr. Jung was a member of the ACADEMY and the Medical Society, and was a frequent contributor to the medical journals, especially on subjects related to digestion and assimilation.

Mr. S. KRUSE, associate electrical engineer at the Bureau of Standards, who has been engaged in radio development work at the Bureau, has been granted a year's leave of absence and has accepted a position with the Hammond Radio Research Corporation, Gloucester, Massachusetts.

Mr. A. A. STEVENSON, chairman of the American Engineering Standards Committee, spoke before the Washington Section of the American Society of Mechanical Engineers on December 9 on *The significance of standardization to industry and the Federal Government*.

Dr. RAYMOND W. WOODWARD has resigned as physicist and chief of the section of mechanical metallurgy of the Bureau of Standards, to becomec hief metallurgist for the Whitney Manufacturing Company of Hartford, Connecticut.

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MINERALOGY.—*Tschermigite (Ammonium Alum) from Wyoming.*

E. THEODORE ERICKSON.[1] U. S. Geological Survey.

INTRODUCTION

A sample of mineral to be tested for potash was received from Mr. C. R. McGregor of the firm of McGregor Brothers Company, contractors and builders, Ogden, Utah. The mineral was identified as tschermigite, natural ammonium alum, and as far as known is the first reported occurrence of this mineral in America. Mr. McGregor has kindly furnished information regarding the deposit of the mineral; it is located about 5 kilometers (3 miles) south of Wamsutter, and 65 Km. (40 miles) west of Rawlins, Wyoming, both places being on the Union Pacific Railroad. The mineral occurs in a 2 meter ledge of black shale and is traceable along the brink of the hills for nearly 5 km. (3 miles).

The writer wishes to express his thanks to Dr. W. T. Schaller for his cooperative interest in the work and preparation of this paper.

ASSOCIATION AND PROPERTIES

In the specimens received by the Geological Survey, tschermigite forms the cementing material holding together seams of pure tschermigite, fragments of brown bituminous shale, nodules of yellow jarosite and a few scattered gypsum crystals. The cementing tschermigite is intimately mixed with the shale fragments and associated minerals. Many of the smaller pieces of shale are rudely rectangular in shape and where these have fallen away, cubic cavities remain in the compact tschermigite. An abundance of pure material suitable for analysis, could readily be obtained from the seams.

The jarosite coats, and in places is inclosed in, the alum, and also forms small pure nodular masses. It is pale yellow in color and very

[1] Published by permission of the Director, U. S. Geological Survey. Received November 3, 1921.

fine grained, the individual crystals and their rhombohedral character being recognized only under the highest magnifying power of the petrographic microscope. The probability of this jarosite containing ammonia was suggested. A carefully selected sample was obtained. largely from the small nodular masses. Treatment with water at room temperature (near 25° C.) yielded 0.87 per cent soluble matter, consisting of some tschermigite, together with a small quantity of jarosite, and a trace of organic matter. If it be considered that the water-soluble content of the jarosite is practically all tschermigite the 0.87 per cent soluble matter would contain only 0.05 per cent ammonia as $(NH_4)_2O$. The jarosite sample was found to contain 1.30 per cent $(NH_4)_2O$, which when corrected for the ammonia in 0.87 per cent of admixed tschermigite, gave 1.25 per cent for the pure jarosite. A lack of suitable material prevented further work being done other than to establish quantitatively the presence of considerable potash and a slight amount of soda. As far as know this is the first recorded occurrence of an ammoniacal jarosite. The small amber colored gypsum crystals are not very abundant and do not present any evidence of unusual composition.

The tschermigite is colorless or white in thick masses and has a clear glassy appearance in small pieces. The mineral is isotropic and the broken pieces do not show any cleavage. The refractive index was found to be 1.457 and the density 1.645. Cornu[2] found the density of the Dux, Bohemia, tschermigite to be 1.636. The artificial ammonium alum has the density 1.626. The value 1.50 given for tschermigite in Dana's System of Mineralogy is obviously too low.

In some of the cavities are small incomplete crystals of tschermigite and some of the columnar masses have a large number of minute facets of the same crystal form along their side. Crystal faces are also present on top of parts of the seams, but nowhere were complete crystals evident. The incomplete crystals were seldom larger than one or two millimeters. The forms noted are $a(100)$, $o(111)$ and $d(110)$, all developed nearly equally, but with a very nonequal development of the different faces of a form on the same crystal.

CHEMICAL COMPOSITION

The mineral readily fuses in its own water of crystallization below the boiling point of toluene (105° C.). It is easily soluble in cold water and gives the usual reactions for ammonium alum. The

[2] Reference given under analysis III.

quantitative analyses were made on a uniform sample of carefully selected material which was practically free from associated mineral and gangue.

The average results obtained are tabulated below (I), together with the theoretical composition of ammonium alum $[Al_2(SO_4)_3.(NH_4)_2SO_4.24H_2O]$ (II), and analyses of the mineral from Bohemia (III, IV).

TABLE 1.—ANALYSES OF TSCHERMIGITE

	I	II	III	IV
	Average analysis of tschermigite from Wyoming	Composition of $[Al_2(SO_4)_3.(NH_4)_2SO_4.24H_2O]$	Tschermigite from Dux, Bohemia	Tschermigite from Brüx Bohemia
Al_2O_3	11.57	11.28	11.40	11.39
$(NH_4)_2O$....	5.23	5.74	5.86[a]	5.62
Na_2O	0.21	.....	0.06	0.17
K_2O........	Trace	.....		
MgO.......	0.13	.....	.....	.....
SO_3........	35.11	35.33	34.99	35.14
H_2O........	47.82	47.65	[47.69[a]]	[47.59[b]]
Insol........	0.06	.....	.....	0.08
Fe_2O_3,CaO,Cl	Trace	.....	.....	0.01[c]
Total	100.13	100.00	100.00	100.00

[a] Given as 3.83 per cent $(NH_4)_2O$, but obviously an error, the 3.83 per cent representing NH_3. The value has been changed to its equivalent (5.86) for $(NH_4)_2O$. The water content given as 49.72 has been correspondingly corrected to 47.69.

[b] Given as 3.67 per cent NH_3 which has also been changed to its equivalent value of 5.62 per cent $(NH_4)_2O$. A correction has likewise been made of the reported water percentage, 49.54 obtained by difference, to 47.59 per cent.

[c] Fe_2O_3.

Analysis III; Deichmüller, J. V., *Neues Vorkommen von Ammonium-alaun.* Sitzb. d. n. Ges. Isis, Dresden, **1885**, 33. Analysis by Geissler. Locality, Vertrau auf Gott mine near Dux, Bohemia. This occurrence is also described by Cornu, F., *Tschermigite von Schellenken bei Dux in Böhmen.* Centr. Min. Geol. **1907**, 467–468.

Analysis IV; Sachs, A., *Über ein neues Tschermigitvorkommen von Brüx in Böhmen, etc.* Centr. Min. Geol. **1907**: 465–467. Locality, Guidoschacht in Nieder-Georgental near Brüx, Bohemia.

A set of four earlier analyses, by Gruner, Pfaff, Lampadius, and Stromeyer, showing similar results, are given by Rammelsberg, in his *Handbuch d. Mineralchemie*, p. 285 (1860). Natural ammonium alum also occurs at Tschermig, Bohemia (from which place the mineral is named); and has been reported from Tokod near Grau, Hungary; Saalfeld in Thuringia; in crater of Mt. Etna with other sulfates; and at Solfatara at Pozzuoli.

The ammonia was determined by the direct distillation of the sample in the customary Kjeldahl apparatus. A gram sample was dissolved in a 500 cc. Kjeldahl flask with 150 cc. of distilled water, an excess strong NaOH solution was then added with the usual precautions and 75 cc. of distillate were slowly received into 25 cc. N/10 H_2SO_4. The excess of acid in the distillate was titrated with N/10 NaOH solution, using methyl orange indicator, the neutralization value of the distilled ammonia being obtained by difference and its percentage computed. Duplicate determinations agreed closely and were corrected for a blank test made on all reagents used.

The mineral was dried to constant weights at temperature intervals between 105° C. and 410° C. inclusive, with the following results. At 105° C. a loss of 36.48 per cent was obtained, which is slightly over three-fourths of the total percentage of water. At 200° C. the remaining water, excepting about one per cent of the total, was given off. At 350° C. a few tenths of one per cent of water are still retained in the residue. Losses in excess of the actual percentage of water commenced near 360° C., and became about three per cent at 410° C. Evidently ammonium sulfate in the double compound commences decomposition near 360° C. which is about 80° C. higher than the decomposition temperature of pure ammonium sulfate.

TABLE 2.—THE LOSS OBTAINED BY HEATING TSCHERMIGITE

Temperature		Percentage of loss	
Toluene bath	(105° C.)	36.48	
Air bath	125° C.	38.07	
	200° C.	47.10	
	215° C.	47.18	
	250° C.	47.26	
	310° C.	47.26	
	350° C.	47.58	Percentage of water in mineral 47.82
	360° C.	47.93	
	410° C.	50.62	

The strongly ignited residue gave a total loss of 88.06 per cent. This loss consisted of the water and ammonia [$(NH_4)_2O$] content together with nearly all of the sulfuric anhydride, a slight amount (0.10) being retained.

In order to interpret correctly the function of the small quantity of substances besides Al_2O_3, retained in the ignited residue, some comparative experiments with a prepared sodium alum were carried out. The percentage of strongly ignited residue from sodium alum was found to be nearly identical with the sum of the percentages of Na_2O

plus Al_2O_3. The average results on the prepared sodium alum are as follows:

TABLE 3

PARTIAL ANALYSIS, THEORETICAL COMPOSITION AND IGNITION RESULTS OF SODIUM ALUM

Partial analysis of the prepared sodium alum		Theoretical percentage of Na_2O + Al_2O_3	Residue obtained by strong ignition	Theoretical percentage of Na_2SO_4 + Al_2O_3.
Na_2O	6.96			
Al_2O_3	11.07	17.91	17.78	26.64
Total	17.76			

Although the ignited residue from the sodium alum contained a small quantity of sulfate which compensates for the loss of a small quantity of volatilized alkali, the result seems to indicate the formation of a sodium aluminate, since in the ignited residue practically all of the sulfate radical is volatilized.

The partial elimination of SO_3 from Na_2O in the ignited residue of tschermigite is thus explained. It is possible that the small amount of $MgSO_4$ in the tschermigite residue reacts in a similar way with the Al_2O_3. However $MgSO_4$ alone in small quantities will dissociate considerably into MgO and SO_3 in the temperature of the ordinary strong blast.

The percentage of water was obtained by subtracting the sum of the $(NH_4)_2O$ and the volatilized SO_3 (the total percentage of SO_3 corrected for SO_3 retained in the ignited residue) from the total loss on ignition. The average results for tschermigite are tabulated below.

TABLE 4.—TOTAL WATER CONTENT OF TSCHERMIGITE

$(NH_4)_2O$		5.23
Total SO_3	35.11	
SO_3 retained in the ignited residue	0.10	
Volatilized SO_3		35.01
		40.24
Total loss upon ignition		88.06
Subtracting the total of $(NH_4)_2O$ and volatilized SO_3		40.24
Water by difference		47.82
IGNITED RESIDUE OF TSCHERMIGITE		
Residue upon ignition		11.94 per cent
Sum of constituents other than Al_2O_3		0.50
Al_2O_3 by difference		11.44 per cent
Al_2O_3 by direct determination		11.57 per cent

The percentage of residue obtained was corrected for the minor nonvolatile constituents, as follows: Na_2O, 0.21 per cent; MgO, 0.13 per cent; nonvolatile insoluble matter, 0.06 per cent, and SO_3 retained in the residue, 0.10 per cent; the sum of which is 0.50 per cent.

BOTANY.—*On the species of* Dalbergia *of Mexico and Central America.* H. PITTIER.[1]

As considered in the light of modern taxonomy, the genus *Dalbergia* includes the former genera *Amerimnon* and *Ecastophyllum.* There is no generic difference between *Amerimnon*, established by Browne in 1756 to include Dalbergias with samaroid pods, and *Ecastophyllum* of the same author and date, containing the species with nummular pods. On the other hand, on the evidence of the generic definition, the species of *Amerimnon* do not fit into *Ecastophyllum*, and species of *Ecastophyllum* cannot come under *Amerimnon.*

In 1781, Linnaeus filius described his new genus *Dalbergia,* which under both the International and the American Rules would not be valid, but for the fact that neither of the two names having the priority really represents a generic entity, but only one part of a single genus, while the later name was intended to apply to both parts.

In this paper, therefore, in accordance with the well founded conclusions given by Prain[2] in his extensive monograph "*The Species of* Dalbergia *of South Eastern Asia,*" the name *Dalbergia* is retained to designate the genus; *Amerimnon* becomes the name of a subgenus, while the species of *Ecastophyllum* are transferred to a single section of the same. This is the view accepted by all European botanists and, I believe, by the majority of those on this side of the Atlantic. In all the recent literature on the subject, including the description of a large number of species old and new, the same name is used, so that the resuscitation of *Amerimnon* as a substitute for *Dalbergia* would cause a great and useless confusion, even omitting the fact that it cannot be applied to the genus as understood today.

In its original form, the present paper included full descriptions of all Mexican and Central American species. Circumstances now have made it necessary to suppress the descriptions of old species and to reduce the paper to a simple enumeration of them, with their known distribution, and to descriptions of only the proposed new species. In addition, the following key has been prepared.

[1] Received December 15, 1921.

[2] Ann. Bot. Gard. Calc. **10**: 10–11. 1904.

KEY TO THE MIDDLE AMERICAN SPECIES OF DALBERGIA

Standard blade straight or hardly reflexed; style short and thick (*Sissoa*).

- Leaflets ovate or oblong-lanceolate, rather large (3 to 11 cm. long); stamens 9.
  - Flowers about 5.5 mm. long, the standard obovate, subauriculate at the base; leaflets 3 to 8 cm. long, 1.5 to 2.5 cm. broad. 1. *D. cubilquitzensis.*
  - Flowers about 3.5 mm. long, the standard ovate or oblong, attenuate at the base; leaflets 4 to 11 cm. long, 2 to 5 cm. broad. 2. D. *tucurensis.*
- Leaflets ovate or ovate-long, rather small (seldom over 4 cm. long); stamens 9 or 10.
  - Stamens 9.
    - Inflorescences loose, dichotomous-paniculate; flowers about 4 mm. long; leaflets ovate, obtuse or subacuminate. Ovary 1-ovulate; standard suborbiculate. 3. *D. melanocardium.*
    - Inflorescences congested, cymose-paniculate.
      - Flowers 3 to 3.5 mm. long; ovary glabrous, 2 or 3-ovulate; leaflets 3 to 5 cm. long. 4. *D. glomerata.*
      - Flowers about 5.5 mm. long; ovary hairy, 1 or 2-ovulate; leaflets 0.5 to 3 cm. long. 5. *D. congestiflora.*
  - Stamens 10.
    - Pistil glabrous.
      - Ovary 4 or 5-ovulate; wings narrow, elongate, the base of the blade truncate, 2-auriculate; leaflets oblong or obovate, whitish and rufo-reticulate beneath. 6. *D. tabascana.*
      - Ovary 1 or 2-ovulate; wings oblique, obovate, 1-auriculate; leaflets ovate, emarginate, ferruginous-pubescent beneath. 7. *D. cibix.*
    - Pistil more or less hairy. Ovary 2 or 3-ovulate.
      - Flowers 5 mm. long, the pedicels 1 mm. long or less; ovary minutely pubescent; standard subauriculate. 8. *D. mexicana.*
      - Flowers 10.5 mm. long, the pedicels 2.5 to 3.5 mm. long; ovary hairy on the margins; standard attenuate at the base. 9. *D. campecheana.*

Standard blade reflexed (with one exception, *D. brownei,* but then leaves 1-foliolate); style slender, often subulate (*Amerimnon*).

Flowers not over 12 mm. long; style geniculate, short and straight; legume orbicular and 1-seeded, or ovate-oblong and 1 to 3-seeded (*Ecastophyllum*).
  Legume ovate-oblong, rounded at the apex, 1 to 3-seeded; flowers about 11 mm. long; standard obovate, straight; leaves 1-foliolate; stamens 10. — 10. *D. brownei.*
  Legume orbicular, 1-seeded; standard orbiculate, reflexed.
    Leaves 1-foliolate; flowers about 10 mm. long; stamens 10. — 11. *D. ecastophyllum.*
    Leaves 3 to 5-foliolate; flowers about 6 mm. long; stamens 9. — 12. *D. monetaria.*
Flowers not less than 14 mm. long; style long and strongly arcuate; legume more or less lanceolate, 1 to 5-seeded. Stamens 10 (*Miscolobium*).
  Leaves entirely glabrous, 5 to 7-foliolate, the leaflets 3 to 4 cm. long. — 13. *D. calycina.*
  Leaves more or less pubescent, 7 to 15-foliolate.
    Leaves and pods hardly changing color in desiccation; leaflets 7 to 11, ovate, glaucous beneath; legume 1 to 5-seeded, rounded-obtuse at the apex. — 14. *D. hypoleuca.*
    Leaves and pods turning black in desiccation.
      Leaflets suborbiculate or broadly ovate, not over 5 cm. long, the margin not revolute. — 15. *D. granadillo.*
      Leaflets ovate or oblong, up to 10.5 cm. long, the margins revolute.
        Flowers about 15 mm. long, the pedicels 4 to 5 mm. long; standard suborbiculate, more or less emarginate at the base. — 16. *D. retusa.*
        Flowers about 16 mm. long, the pedicels about 5 mm. long; standard ovate or oblong, attenuate at the base. — 17. *D. lineata.*

ENUMERATION OF SPECIES

1. Dalbergia cubilquitzensis (Donn. Smith) Pittier.

Dalbergia variabilis var. *cubilquitzensis* Donn. Smith, Bot. Gaz. **57**: 417. 1914.

TYPE LOCALITY: Cubilquitz, Alta Verapaz, Guatemala, altitude about 350 m. (*von Tuerckheim* 4091).

OTHER SPECIMENS EXAMINED:

GUATEMALA: Los Amates, Department Izabal, 1905, *Kellerman* 4789.

This species, considered by Mr. Donnell Smith as a mere variety of *D. variabilis* Vogel, differs from this in the pubescence, the shape and size of the

calyx lobes, the shape of the petals, the number of stamens, the shape and size of the leaves and leaflets, etc.

2. **Dalbergia tucurensis** Donn. Smith, Bot. Gaz. **46:** 111. 1908.

TYPE LOCALITY: Concepción near Tucuón, Alta Verapaz, Guatemala (*von Tuerckheim* II. 1712).

3. **Dalbergia melanocardium** Pittier, sp. nov.

Medium sized tree; branchlets terete, ferruginous pubescent, later glabrate and grayish.

Leaves 7 to 11-foliolate, the rachis terete, minutely pilosulous, 4 to 13 cm. long. Leaflets subcoriaceous, the petiolules sparsely ferruginous-pubescent, 3 to 4 mm. long, the blades ovate, rounded or subacute at the base, obtuse and subretuse at the apex, 1.5 to 4.5 cm. long, 1.3 to 2.5 cm. broad, dark green and pilosulous above, paler or rufescent, ferruginous-pubescent and reticulate beneath, the very slender veins prominent on both faces.

Inflorescences paniculate, axillary and terminal, congested, shorter than the leaves, the branched rachis ferruginous-pubescent. Bractlets small, ovate or orbiculate, ferruginous-pubescent. Flowers sessile or short pedicellate, about 4 mm. long. Calyx subbilabiate, broad, fulvous-hairy, about 2.5 mm. long, the two vexillar lobes broad and rounded, the 2 lateral ones equally long and obtuse, but narrower, the carinal one about twice longer, obtuse or bilobulate. Petals glabrous; standard suborbiculate, the claw oblique, 0.8 to 0.9 mm. long, the blade subbiauriculate at the base, emarginate at the apex, about 3 mm. long and broad; wings free from the keel, auriculate on both margins at the base, obtuse at the apex, about 4 mm. long (including the claw) and 1.4 mm. broad; carinal petals broader than the wings, ovate, auriculate on the vexillar side, obtuse, about 3.8 mm. long, 1.5 mm. broad. Stamens 9, monadelphous, the staminal tube glabrous, open above. Pistil 4.5 to 5 mm. long, the ovary stipitate, 1-ovulate, ferruginous-villous, the style thick, arcuate, glabrous, the stigma inconspicuous.

Type in the U. S. National Herbarium, no. 258410, collected at Ojo de Agua, Department of Santa Rosa, Guatemala, altitude about 900 meters, May, 1892, by Heyde and Lux (J. D. Smith 3295).

Known among the natives under the name of "Ébano," and distributed as *Dalbergia variabilis* Vogel. Like this species it has a calyx with two broad more or less connate upper lobes, and three narrower lower lobes, the middle (carinal) one about twice longer, but obtuse or retuse. But the flowers are sessile, shorter and broader, there are 9 stamens, the ovary is densely villous-hairy and the congested inflorescence is not cymose.

4. **Dalbergia glomerata** Hemsl. Diag. Pl. Nov. **1:** 8. 1878.

TYPE LOCALITY: Sangolica, Mexico (*Botteri* 1027).

5. **Dalbergia congestiflora** Pittier, sp. nov.

Small tree, 3 to 4 m. high; branchlets terete, striate, sparsely lenticellate, at first minutely grayish-pubescent.

Leaves 7 to 13-foliolate, the rachis slender, sparsely pubescent, 4 to 11 cm. long. Leaflets subcoriaceous, the petiolules pilosulous, 2 to 3 mm. long, the blades ovate-oblong, broadly cuneate at the base, rounded, slightly emarginate and sometimes mucronulate at the apex, 0.5 to 3 cm. long, 0.3 to 2.3 cm. broad, sparsely pilosulous on both faces, reticulate and with the venation prominulous above, beneath lineate-reticulate, the costa and veins prominent.

Inflorescences paniculate, cymose-branched, axillary or terminal on defoliate branchlets, congested, not over 3 cm. long, the rachis densely ferruginous-hairy. Bracts and bractlets oblong, ferruginous-hairy, very small, caducous. Flowers pedicellate, 5.5 mm. long, the pedicels 1 to 1.5 mm. long. Calyx subcampanulate, 2 to 2.5 mm. long, sparsely pubescent, the 2 vexillar lobes broad, rounded and adnate, the lateral lobes narrower and acute, the carinal lobe apiculate and longer. Petals glabrous; standard ovate or oblong, more or less attenuate at the base, emarginate at the apex, 3.6 mm. long, 1.4 to 1.6 mm. broad; wings elongate, oblique, more or less attenuate at the base, rounded at the apex, about 3 mm. long, 0.9 to 1.1 mm. broad; carinal petals ovate, auriculate on the vexillar side, obtuse at the apex, the claw about 0.8 mm. long, the blade about 2.5 mm. long, 1.5 to 1.8 mm. broad. Stamens 9, glabrous. Pistil 2.5 to 3 mm. long, hairy, ciliate on the margins, the ovary 1-ovulate (?), the style short and thick, the stigma inconspicuous.

Type in the U. S. National Hebarium, no. 381855, collected on lava fields near Cuernavaca, Morelos, Mexico, altitude about 1650 m., March 17, 1899, by C. G. Pringle (no. 6981).

Distributed as *Dalbergia glomerata* Hemsley, but the leaves are much smaller, the leaflets less numerous, more than half smaller, pilosulous on both faces, the flowers are larger, the standard is sensibly longer than the wings and keel and not suborbiculate but ovate or distinctly oblong, the ovary is apparently 1-ovulate, etc.

6. **Dalbergia tabascana** Pittier, sp.

Shrub (?); branchlets grayish, sparsely lenticellate, at first minutely grayish-pubescent.

Leaves 6 or 7-foliolate, the rachis slender, minutely pilosulous, 3 to 3.5 cm. long. Leaflets subcoriaceous, the petiolules minutely pubescent, 1 to 1.5 mm. long, the blades oblong or obovate, rounded at the base and apex, 1 to 2.5 cm. long, 0.5 to 1 cm. broad, dark green and glabrous above, whitish or rufescent, rufo-reticulate and minutely pilosulous beneath.

Inflorescences few-flowered, subcymose, axillary or paniculate at the end of the branchlets, the rachis branched, sparsely gray-pubescent. Bracts and bractlets ovate-oblong, pubescent, not over 1 mm. long, caducous. Flowers pedicellate, about 9 mm. long, the pedicels minutely gray-pubescent, 2 to 4 mm. long. Calyx tubular-campanulate, 3.5 to 4 mm. long, sparsely pubescent or glabrescent at the base, pubescent on the lobes, subbilabiate, the carinal lobe apiculate, not much longer than the vexillar ones, these obtuse, the lateral ones smaller and acute. Petals glabrous; standard obovate-oblong, straight, attenuate and subauriculate at base, rounded and slightly emarginate at apex, the claw about 2 mm. long, the blade 5.5 mm. long, 1.6 mm. broad; wings elongate-oblong, auriculate on the vexillar side, subauriculate on the carinal side, rounded at apex, the claw 2 mm. long, the blade about 5.5 mm. long, 1.6 mm. broad; carinal petals falcate, auriculate on the vexillar side, obtuse at the apex, the claw 2.2 mm. long, the blade about 4 mm. long and 1.8 mm. broad. Stamens 10, monadelphous, glabrous, alternately short and long. Pistil about 6 mm. long, glabrous, the ovary long-stipitate, 4 or 5-ovulate, the style oblique, straight, the stigma subcapitellate.

Type in the John Donnell Smith Herbarium, collected in inundated places near Mayito, Tabasco, Mexico, August 17, 1889, by J. N. Rovirosa (no. 583).

The type specimen is labelled *Dalbergia campecheana* Benth., but the leaves are small, with few, distinctly petiolulate leaflets, the inflorescences are few-flowered, the ovary is 4 or 5-ovulate, etc.

7. Dalbergia cibix Pittier, sp. nov.

Scandent shrub or vine, ascending to 20 m. above the ground; branchlets terete, grayish, more or less lenticellate, at first densely ferruginous-pubescent.

Leaves 7 to 9-foliolate, the rachis terete, slender, ferruginous-hirtous, 4 to 5 cm. long. Leaflets submembranous, the petiolules ferruginous-pubescent, about 1.5 mm. long, the blades ovate, rounded at the base, rounded and slightly emarginate at the apex, 1 to 2 cm. long, 0.6 to 1.3 cm. broad, sparsely pilosulous and minutely reticulate above, beneath densely ferruginous-pubescent, the costa prominent and the veins impressed; margins revolute.

Inflorescences paniculate, many-flowered, axillary, terminal or more or less fasciculate on defoliated nodes, the rachis branched, ferruginous-hairy. Bracts and bractlets suborbiculate, pubescent, 1 mm. long or less, caducous. Flowers pedicellate, white, about 7 mm. long, the pedicels 1 to 1.5 mm. long. Calyx subtubular, bilabiate, 2.5 to 3 mm. long, sparsely pubescent, the 2 vexillar lobes broad, rounded and adnate, the 2 lateral lobes small andacute, the carinal lobe narrow, acute, twice as long as the others. Petals pink (?), glabrous; standard oblong, hardly auriculate at the base, emarginate, the lobes rounded at the apex, the claw 1.2 mm. long, the blade 5.5 mm. long, 3.3 mm. broad; wings oblique, obovate, auriculate on the vexillar margin at the base, obtuse at the apex, the claw about 1.5 mm. long, the blade 4.5 to 5 mm. long, about 2 mm. broad; carinal petal subfalcate, auriculate on the vexillar side, subacute, the claw as in the wings, the blade 3.2 mm. long, 1.5 mm. broad. Stamens 10, monadelphous, alternately long and short, glabrous. Pistil about 5 mm. long, glabrous, the ovary stipitate, 1 or 2-ovulate, the style slightly arcuate, truncate at the apex.

Legume ovate-oblong, membranous, attenuate at the base in a short, slender stipe, rounded at the apex, 1-seeded, 4.5 to 6 cm. long, 1.5 to 1.7 cm. broad, glabrous. Seeds immature.

Type in the U. S. National Herbarium, no. 571750, collected at Yaxcaba, Yucatán, Mexico, 1895, by G. F. Gaumer (no. 721).

According to a communication of Dr. Millspaugh, the fruits just described, which bear the no. 57934, were collected at a different place by Dr. Gaumer but referred to the above species, under no. 721.

The Maya name of these pods is "Kuxub-tooch," that of the type specimens "cibix."

8. Dalbergia mexicana Pittier, sp. nov.

Branchlets terete, finely striate, ferruginous-puberulous, glabrate.

Leaves 9 to 11-foliolate, the rachis terete, slender, sparsely ferruginous-pubescent, 5 to 7 cm. long. Leaflets subcoriaceous, the petiolules ferryginous-hairy, about 2 mm. long, the blades ovate, or sometimes suborbicular or obcordate, rounded at the base, rounded-emarginate at the apex, 1 to 4 cm. long, 1 to 2 cm. broad, dark green, lustrous, reticulate, glabrous or sparsely ferruginous, reticulate and sparsely pubescent beneath, the costa subimpressed on both faces, the veins prominulous above, obsolete beneath.

Inflorescences axillary, very short (not over 2 cm. long), few-branched, the ramifications subcymose, the rachis ferruginous-hairy. Bractlets ovate, acute, hairy, not over 0.5 mm. long. Flowers pedicellate, about 5 mm. long,

the pedicels hairy, 1 mm. long or less. Calyx cupulate, 2 to 3 mm. long, sparsely hairy at the base, more so on the lobules; vexillar lobules subacute and broad, lateral lobules small, acute, close to the carinal one and separated from the former by deep sinuses; carinal lobule subulate, twice as long as the vexillar ones. Petals glabrous; standard obovate, subbiauriculate at the base, slightly emarginate at the apex, the claw 1.2 mm. long, the blade 4.2 to 4.6 mm. long, 3 to 3.3 mm. broad; wings obovate, rounded-auriculate on the vexillar side, subauriculate on the carinal side, rounded at the apex, the claw 1.2 or 1.3 mm. long, the blade about 4 mm. long, 1.7 or 1.8 mm. broad; carinal petals obovate, auriculate on the vexillar side, rounded at the apex, the claw 1.3 to 1.5 mm. long, the blade about 3 mm. long, 1.5 mm. broad. Stamens 10, monodelphous, the tube open above, glabrous. Pistil 4.8 mm. long, the ovary minutely pubescent on the margins, 2 to 3-ovulate, the style arcuate, glabrous, the stigma inconspicuous.

Type in the John Donnell Smith Herbarium, collected in Mexico, without definite locality, by E. Kerber (no. 434).

9. Dalbergia campecheana Benth. Journ. Linn. Soc. **4:** Suppl. 37. 1860.

Type Locality: Campeche, Mexico.

Specimens Examined:

Guatemala: Aquascalientes, 1909, *Deam* 6125.

Mr. J. Donnell Smith identified these specimens with Bentham's above named species. This, however, seems to have larger leaves, with 7 to 19 almost sessile leaflets, while in Deam's specimens these are 9 to 11 and petiolulate. The other characters seem to agree.

10. Dalbergia brownei (Jacq.) Urban, Symb. Antill. **4:** 295. 1905.

Amerimnon brownei Jacq. Enum. Pl. Carib. 27. 1760.

Dalbergia amerimnum Benth. Journ. Linn. Soc. **4:** Suppl. 36. 1860.

Type Locality: Jamaica.

Specimens Examined:

Venezuela: Puerto Cabello, 1874, *Kuntze* 1721.

Columbia: Negüangüe, on the coast between Santa Marta and Rio Hacha, 1898, *H. H. Smith* 1750. Dagua Valley, Cauca, altitude 25 meters, *Triana* 1130.

Panama: Providence Island, Bocas del Toro, 1885, *Hart* 182. Beach between Fató and Playa Damas, 1911, *Pittier* 3834. Rio Grande swamps, near Panama City, *Hayes*. La Palma, southern Darién, 1914, *Pittier* 6613. Coiba Island, *Seemann* 626.

Costa Rica: Ceibo River near Buenos Aires, altitude 200 meters, 1892, *Tonduz* 6675. Santo Domingo de Osa, 1896, *Tonduz* 9892.

Nicaragua: San Juan del Norte, 1895, *Pittier* 9658.

Guatemala: Boca del Polochic, Department Izabal, 1889, *J. D. Smith* 1708. Livingston, 1906, *von Tuerckeim* II. 1216.

Mexico: Veracruz, 1910, *Adole* (?). Tampico, 1898, *Pringle* 5764, 6809. Rincón Antonio, Oaxaca, 1910, *Orcutt* 3263.

Several species may be included under this name. According to Bentham, it is a tree; Tonduz describes it as a shrub (arbrisseau); while H. H. Smith says it is a "twining plant, reaching 30 feet, with a prickly main stem and 2 inches or more in diameter." In my own notes, no. 3834 is described as "a shrubby vine, with white flowers," and no. 6613, as a small tree branching from

the base." The only fruits at hand differ a little from Bentham's description, and in Donnell Smith no. 1708, from Guatemala, I find the petals narrower, the standard auriculate, the ovary 5-ovulate and other small differences.

Although distinctly characteristic of the strand formation, *Dalbergia brownei* is sometimes found far above sea-level. H. H. Smith observed it, for instance, up to about 700 meters in Santa Marta.

11. Dalbergia ecastophyllum (L.) Taub. in Engl. & Prantl, Pflanzenfam. 3^3: 335, 1894.

Hedysarum ecastophyllum L. Syst. ed. 10, **2**: 1169. 1759.

Ecastaphyllum brownei Pers. Syn. **2**: 277. 1807.

TYPE LOCALITY: West Indies.

SPECIMENS EXAMINED:

TRINIDAD: Port of Spain, 1874, *Kuntze* 764.

VENEZUELA: Paparo, mouth of Rio Grande del Tuy, Barlovento, Miranda, 1913, *Pittier* 6349.

COLOMBIA: Santa Marta, 1914, *Sinclair.*

PANAMA: Chagres, 1854, *Fendler* 315. Colon, *Hayes* 155. Without definite locality, 1874, *Kuntze* 764.

COSTA RICA: Boca Banano, 1895, *Tonduz* 9156. Diquis River, 1891, *Tonduz* 4014. Punta Mala, in the Diquis delta, 1892, *Tonduz* 6775. Santo Domingo de Osa, 1896, *Tonduz* 9892.

GUATEMALA: Puerto Barrios, 1905, *Deam* 59.

HONDURAS: Puerto Sierra, 1903, *Wilson* 248. Ruatán Island, 1886, *Gaumer.*

BRITISH HONDURAS: Manatee Lagoon, 1906, *Peck* 463.

Dalbergia ecastophyllum has also been reported from many localities from Rio de Janeiro northwards and including the Guianas on the Atlantic seaboard of South America, from all over the West Indies, and from Florida. It is worthy of notice that this shrub does not seem to have been recorded from Mexico.

12. Dalbergia monetaria L. f. Suppl. 317. 1781.

TYPE LOCALITY: Surinam.

SPECIMENS EXAMINED:

FRENCH GUIANA: Karouany, *Sagot* 159.

VENEZUELA: Bosque de Catuche, above Caracas, 1913, *Pittier* 6297.

PANAMA: Rio Sirri, Trinidad Basin, province of Colón, near sea-level, 1911, *Pittier* 4029.

HONDURAS: Tela River, near Puerto Sierra, 1903, *Wilson* 77. Laguna Quemada, Atlantic Coast, 1903, *Wilson* 627.

GUATEMALA: Puerto Barros, 1905, *Deam* 70.

This species is scarcer in Central America than either *D. brownei* or *D. ecastophyllum.* It does not figure in the Biologia Centrali-Americana, and, since the publication of this work, has been reported only from a few localities as shown above, all on the Atlantic seaboard, from Guatemala southeastwards. It is found also in the West Indies and on the eastern watershed of South America as far south as the Amazon basin. It penetrates far into the interior along the main rivers, and in the vicinity of Caracas reaches an altitude of about 1200 meters.

Unless it has been incorrectly stated, the habit of this species is very variable. Some report it as a shrub or small tree up to 3 meters high; Bentham[3] says "caulis lignosus vulgo scandens;" and the notes corresponding to my no. 6297 from near Caracas are as follows: "a large vine, often 15 cm. in diam. at the base and climbing to the top of the highest trees." The shape of the fruit is also different in specimens from different localities, although I have never seen the oblong type reproduced in plate 63 of the work just cited. With reference to this plate it may be opportune to mention that although Bentham indicates only 9 stamens, as always found by myself, he gives two illustrations of the androecium of *D. monetaria*, each with 10 stamens.

13. **Dalbergia calycina** Benth. Journ. Linn. Soc. 4: Suppl. 35. 1860.

TYPE LOCALITY: Guatemala (*Friedrichsthal*).

14. **Dalbergia hypoleuca** Pittier, sp. nov.

Tree; young branchlets ferruginous-pubescent.

Leaves 7 to 11-foliolate, the rachis terete, pubescent, glabrescent, 10 to 20 cm. long. Leaflets coriaceous, often opposite or subopposite, the petiolules canaliculate, grayish-pubescent, 5 to 7 mm. long, the blades ovate or ovate-oblong, rounded at the base, obtuse and subretuse at the apex, 3 to 7 cm. long, 2 to 3 cm. broad, glabrous and finally reticulate with the venation prominulous above, beneath grayish or whitish, minutely pubescent, with the costa very prominent and the veins slightly so; margins strongly revolute.

Inflorescence axillary or terminal. Flowers not known.

Legume coriaceous, glabrous, long-stipitate, rounded-attenuate at the base, rounded and mucronulate at the apex, 1-seeded and then 8 cm. long and 2 cm. broad, or 2 to 5-seeded and up to about 16 cm. long, the breadth varying between 1.7 and 1 cm.

Type in the John Donnell Smith Herbarium, collected at El Escobal, near Atenas, Costa Rica, by Federico Golcher. Represented also in the U. S. National Herbarium (no. 716263) by the same collection, without date, and numbered 1747, which probably corresponds to the series of the Instituto físico-geográfico.

This is the Costa Rican *Cocobola*, equal in value to that of Panama, but even scarcer. It is probably a close relative of the latter, but the leaflets are less numerous, and the pods much narrower.

15. **Dalbergia granadillo** Pittier, sp. nov.

Tree. Leaves 7 to 13-foliolate, the rachis terete, at first pubescent, 9 to 17.5 cm. long. Leaflets submembranous, often subopposite, the petiolules sparsely pubescent or glabrescent, canaliculate, 4 to 5 mm. long, the blades suborbiculate or ovate, broadly rounded at the base, obtuse or subacuminate at the apex, 3 to 5.5 cm. long, 2 to 4 cm. broad, glabrous and reticulate with the venation prominulous above, glabrous except on the prominent, sparsely pubescent costa, and the veins prominulous, beneath; margins not revolute.

Inflorescence paniculate, axillary or terminal, the rachis few-branched, ferruginous-pubescent. Flowers few. Calyx cupulate, ferruginous-pubescent, persistent. Other floral details not known.

[3] In Mart. Fl. Bras. 15^1: 229. 1862.

Legume lanceolate, long-stipitate, attenuate at the base, acute at the apex, glabrous, lustrous, 1-seeded and about 9 cm. long and 1.8 or 2 cm. broad, or 2 to 4-seeded and then up to 17.5 cm. long. Seeds oblong-reniform, not mature.

Type in the Gray Herbarium, collected at El Tibor, in the valley of the Balsas River (between the States of Guerrero and Michoacan), Mexico, August 22, 1898, by E. Langlassé (no. 294).

Like *D. retusa* and *D. hypoleuca*, this species furnishes a precious wood, which is hard, fine, and red-veined, and is known locally as *granadillo*.

The specimens at hand are hardly satisfactory for a description, but they belong to a section heretofore not known to be represented in Mexico, and differ from the other Middle American species of the group in the shape, consistence and indument of the leaflets, and in the shape and appearance of the pods. It is consequently pretty safe to consider them as corresponding to a type specifically distinct.

16. Dalbergia retusa Hemsl. Diagn. Pl. Nov. **1**: 8. 1878.

TYPE LOCALITY: Paraiso, Panama (*Hayes* 642).

SPECIMENS EXAMINED:

PANAMA: Penonomé, Coclé, 1908, *Williams* 425. Chagres River above Alhajuela, 1911, *Pittier* 3511. Vicinity of La Palma, southern Darién, 1914, *Pittier* 6606.

COSTA RICA: Salinas Bay, between the littoral plain and La Cruz de Guanacaste, 1908, *Pittier* 2737.

This is the Panama "cocobola," a hard wood very well known commercially and obtained probably from several species of the same genus. I have seen no specimens from the type collection, but ours agree generally with the description. The leaflets, however, are more numerous and not usually retuse and the flowers seem to be smaller.

In Panama this tree has been exploited with such diligence as to have become very scarce in the central and western districts. In 1914 the more important logging camps were at Sumacate and Rio Congo in Darien.

17. Dalbergia lineata Pittier, sp. nov.

Large deciduous tree with rounded crown; young branchlets minutely fuliginous-pubescent.

Leaves 8 to 15-foliolate, the rachis 8 to 20 cm. long, more or less fuliginous-pubescent. Leaflets petiolulate, at first membranous, often opposite or subopposite, the petiolules grayish-hairy, about 7 mm. long, the blades ovate or oblong, cuneate or attenuate at the base, obtuse at the apex, 4 to 8 cm. long, 2 to 3.5 cm. broad, glabrous above, with the costa and veins prominent, densely grayish-pubescent beneath. Stipules ovate, acute, fuliginous-pubescent without, up to 7 mm. long and 3 mm. broad, very caducous.

Inflorescences paniculate, axillary or terminal, few-flowered, the rachis fuliginous-pubescent, 4 to 15 cm. long. Bracts and bractlets fuliginous-hairy, very caducous, the latter oblong, obtuse, not over 1 mm. long, inserted in pairs close to the calyx. Flowers about 16 mm. long, the pedicels densely fuliginous-hairy, about 3 mm. long. Calyx cupulate, 5 to 6 mm. long, densely pubescent, the vexillar lobes broader, equal in length to the lateral ones, the

carinal lobe linear-apiculate and longer. Petals white, delicately purple-lined, glabrous; standard strongly reflexed, ovate, attenuate at the base, emarginate at the apex, the claw 3 mm. long, the blade 10 mm. long, 8.5 mm. broad; wings obovate, oblique, auriculate on the vexillar side, the claw 3.5 mm. long, the blade 11.5 mm. long, 4.5 mm. broad; carinal petals falcate, auriculate on the vexillar side, obtuse at the apex, the claw as in the wings, the blade about 10 mm. long, 4 mm. broad. Stamens 10, monadelphous, alternately long and short. Pistil about 13 mm. long, glabrous, the ovary long-stipitate, linear, 4 to 6-ovulate; style strongly arcuate; stigma capitellate, inconspicuous.

Type in the U. S. National Herbarium, no. 577918, collected at Nicoya, Costa Rica, April, 1900, by A. Tonduz (no. 13969).

A specimen (Inst. fis.-geogr. n. 13887), obtained by the same collector from the forest of Nicoya, is probably the same species. However, the specimens are leafless and floral panicles larger and many-flowered. Mr. Tonduz says that the tree they proceed from is a preponderant one in the forests of the peninsula, being gregarious and giving a characteristic bluish-gray color to the forests in April, the flowering time.

The affinities of this species are evidently with *Dalbergia retusa* Hemsley.

ELECTRICITY.—*Electromotive force of cells at low temperatures.*[1] G. W. VINAL AND F. W. ALTRUP, Bureau of Standards.

The practical importance of a knowledge of the electromotive behavior of dry cells and storage batteries at low temperatures has arisen from their use in the Arctic and at high altitudes. In June, 1921 the Department of Terrestrial Magnetism of the Carnegie Institution, of Washington, through Dr. S. J. Mauchly, requested the Bureau of Standards to furnish information in answer to the following questions: (a) What is the open circuit voltage of dry cells at approximately 0° Fahrenheit and below? (b) Are dry cells fit for use after they have been frozen and thawed out again? Since there was no reliable information available on this subject, experimental work was undertaken which included observations on storage batteries also. In the first experiment the temperature range was extended to −72° C. and as the open circuit voltage of the cells was not materially changed by cooling them to this temperature, the work was extended to −170° C. because of the theoretical interest in the application of the Gibbs-Helmholtz and Nernst equations to these cells.

Two methods of cooling the cells were employed. For the range +25° to −72° C., the cells were submerged in a gasoline bath to which small amounts of carbon dioxide snow were added gradually until the

[1] Published by permission of the Director of the Bureau of Standards. Received January 6, 1922.

lowest temperature attainable by this means was reached, when an excess of the snow was packed around the cells. For the range +20° C. to −170° C. liquid air was used for cooling. The dry cells were placed in a double walled glass jacket similar to a Dewar vessel, but having air at atmospheric pressure between the walls. This was submerged in liquid air contained in a larger Dewar flask. The storage cell, contained in a glass test tube, was similarly arranged with the addition of a ground-cork packing to protect it from breakage. By this means the cooling was gradual, about 2 hours being required for the cells to fall from room temperature to the lowest temperature available.

The temperature was measured by a thermocouple of standardized constantan and copper wire. Since it was not practicable to insert the thermocouple in the dry cells of which the e.m.f. was measured, the thermocouple was placed at the center of a similar dry cell which was grouped symmetrically with the other cells. The temperature of the storage cell was measured by placing the thermocouple, protected by a thin-walled glass tube, in the electrolyte between the positive and negative plates of the cell. The electromotive forces of the thermocouples were read on a high resistance potentiometer.

The dry cells measured were $^3/_4$ inch diameter × $2^1/_8$ inch high, taken from flashlight batteries of a well known make. A few experiments on silver chloride dry cells were made also. The storage cells were made by cutting strips of suitable size from the pasted plates of an automobile starting and lighting battery. These were placed in test tubes about 1 inch in diameter with perforated hard rubber separators and a few glass beads. The electrolyte was adjusted to a specific gravity of 1.275 to 1.280 at the end of 5 days of continuous charging at 0.4 ampere.

The voltage of the cells during test was measured by 3 different methods but the open-circuit measurements at the lowest temperatures could be made only by an electrometer. This instrument was loaned to us by the Department of Terrestrial Magnetism. The open circuit voltages were also measured on a 20,000-ohm potentiometer which afforded a very sensitive method before the cells were frozen although after this it was nearly useless. A voltmeter having a scale of 2.5 volts and a resistance of 25,000 ohms was used for some of the measurements.

The results of experiments with dry cells of the ordinary type are shown in Table 1 and Fig. 1. Curves A and B represent the open-

circuit voltages as measured for two different cells by the electrometer and the potentiometer. Curves C, D, E and F represent the terminal voltage when the cells were discharging through 25,000, 100, 25 and 4 ohms, respectively. The curves indicate the existence of a critical point at about $-21°$ C.

The open-circuit voltage curves indicate that changes in the temperature coefficient occur at certain temperatures. Between $+26°$ and $0°$ C. the coefficient was found to be constant and somewhat less than a millivolt per degree. The coefficient is positive, that is, increase in temperature is accompanied by increase in voltage. Between $0°$

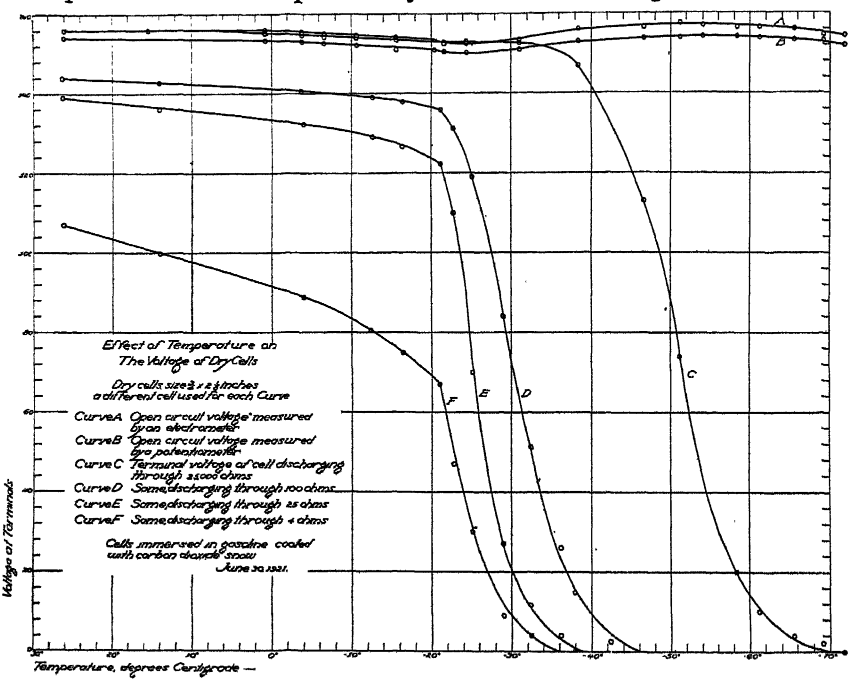

Fig. 1. Effect of temperature on the voltage of dry cells.

and $-20°$ C. the coefficient is still positive, but larger. At $-20.4°$ C. a break occurs. The temperature coefficient becomes much larger during the next few degrees and then changes to negative at about $-24°$. At $-54°$ the coefficient again becomes positive. It is interesting to note that at $-54°$ C. the voltage is higher than at ordinary temperatures.

Curves C, D, E and F show that the ordinary dry cell can deliver current down to about $-20°$ C., below which the voltage falls off rapidly to zero.

Silver chloride dry cells were measured in a similar manner, and the open circuit voltages are given in Table 1. When the voltage was measured by the 25,000-ohm voltmeter, however, the terminal voltage began to fall rapidly from 0° C. downward. At −10° it was 0.9 volt, and from this point it decreased nearly linearly to 0.05 volt at −50°.

Experiments were also made to determine the voltage of storage cells within the range +25° to −72° C., using the electrometer, the potentiometer and the voltmeter to measure the voltage. As freezing did not occur within this range, the potentiometer gave the most accurate results and these are given in Table 1, but the results of all

TABLE 1.

OPEN CIRCUIT VOLTAGES OF CELLS FOR VALUES BELOW −70° C. SEE FIG. 2

Temperature	Ordinary* dry cell	Storage* cell	Silver** chloride cell
°C.	Volts	Volts	Volts
20	1.540	2.116	1.06
10	1.537	2.113	1.05
0	1.533	2.111	1.04
−10	1.523	2.107	1.03
−20	1.512	2.103	1.02
−30	1.508	2.100	1.01
−40	1.530	2.096	1.00
−50	1.540	2.092	0.99
−60	1.540	2.087	0.98
−70	1.526	2.081	0.97

* Based on potentiometer readings.

** Interpolated values based on electrometer readings.

methods were in good agreement. The temperature coefficient was small and constant. This fact permitted an accurate estimate of the temperature coefficient to be made since the cell had sufficient time for thermal equilibrium to be established at the beginning and end of this range. The temperature coefficient was found to be 0.000398 volt per degree C.

It is interesting to compare this result with the value computed from the available thermochemical data and the Gibbs-Helmholtz equation. This equation is usually written

$$Q = W - T\frac{dW}{dT} \qquad (1)$$

where Q is the heat of the reaction; W the available work and T the absolute temperature. This equation is applicable to a reversible cell in which the passage of current does not involve any appreciable

change in volume. If E denotes the open circuit voltage of the cell W equals 96500 E volt-coulombs[2] for 1 equivalent. Q expressed in calories may be converted to voltcoulombs by multiplying by 4.183 and the equation becomes:

$$\frac{dE}{dT} = \frac{1}{T} (E - 0.000021674\ Q). \qquad (2)$$

Both E and Q are dependent on the concentration of the electrolyte which for this experiment was of 1.280 sp. gr. The value of E corresponding to the initial value T was observed directly. The value for Q may be calculated from published thermochemical data.

The commonly accepted reaction of the lead accumulator during discharge may be described by the following equation:

$$\left.\begin{array}{ll} \text{Positive plate,} & PbO_2 + H_2SO_4 \\ \text{Negative plate,} & Pb + H_2SO_4 \end{array}\right\} + n.H_2O \longrightarrow 2PbSO_4 + (n+2)H_2O$$

where n is the number of molecules of water to 2 molecules of sulphuric acid in the original solution. The corresponding thermochemical equation is

$$PbO_2 + Pb + 2H_2SO_4 + n.H_2O = 2PbSO_4 + (n+2)H_2O + Q_n$$

where Q_n, the heat of the reaction, depends on the dilution of the acid, which is fixed by n. Since the chemical reaction must take H_2SO_4 from the dilute electrolyte, the energy represented by Q_n for other strengths of acid will be less in amount by the quantity of heat evolved by dilution of the acid, or Q_n will be greater if the concentration is greater.

Values for Q have been determined by Streinz[3] and Tscheltzow[4] to be 87000 and 88600 calories, respectively. The mean of their determinations is 87800 calories. Dolezalek[5] states that these values apply to dilute sulphuric acid (1 molecule of H_2SO_4 to about 400 molecules of H_2O) and hence a correction for the heat of dilution is necessary. The heat of dilution[6] of the acid solution from a specific gravity of 1.280 as used in our experiment to the concentration equivalent to 1 molecule of acid to 399 mols.of water is 2210 calories per gram molecule. Two gram molecules are involved and hence the value for

[2] The value 96500 coulombs is based on recent determinations with the silver and iodine voltameters by Vinal and Bates at the Bureau of Standards, Sci. Paper No. **218**.

[3] Wied. Ann. **53**: 698. 1894.

[4] Comptes Rendus **100**: 1458. 1885.

[5] *Theory of the Lead Accumulator*, p. 29.

[6] Thomsen's data, Landolt and Bornstein tables, ed. 4, p. 885.

the heat of the reaction for an electrolyte of 1.280 specific gravity is $87800 + 4420 = 92220$ calories.

The value for E at 25° C. and electrolyte of specific gravity 1.280 was 2.120 volts. The temperature, 25° C., corresponds to 298° absolute. Substituting these values for T, E and Q in equation (2) the value for the temperature coefficient dE/dT is found to be 0.0004.07 The results of the experiment showed a decrease in the open circuit voltage of 0.0386 volt when the temperature was decreased 97° from which $dE/dT = 0.000398$.

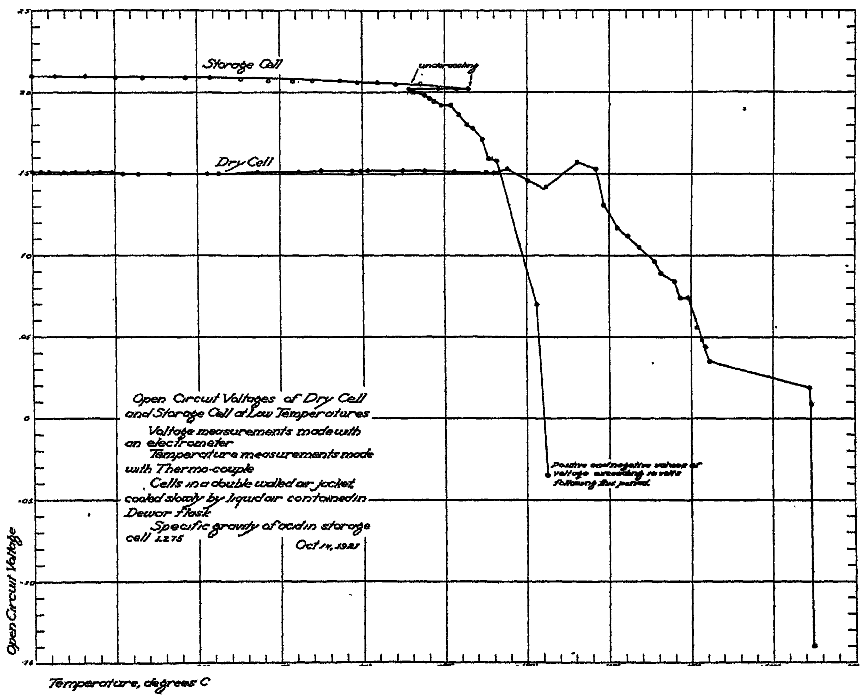

Fig. 2. Open circuit voltages of dry cell and storage cell of low temperatures.

The agreement of this observed value with that calculated from thermochemical data is better than would be expected and gives a striking proof of the validity of the Gibbs-Helmholtz equation over a wide range of temperature.

A second series of measurements extending the temperature range down to −170° C. was then made. Only the electrometer readings are of value at this low temperature. The results on a dry cell and a storage cell are shown graphically in Fig. 2. These are the open circuit voltages measured electrostatically. The storage cell showed

marked under-cooling of the electrolyte before freezing began. The dry cell showed a considerable increase in voltage at $-112°$ C. over the normal value. The most remarkable facts are the reversal of voltages and the extraordinarily large values of voltage exhibited by the storage cell, exceeding ten volts at the lowest temperatures. The current was of course vanishingly small.

Nernst's equation applied to the storage battery in accordance with Liebenow's theory[7] is as follows:

$$E = \frac{RT}{2} \ln \frac{C_p C_n}{[Pb^{++}][PbO^{--}]}$$

where C_p and C_n are the solution tensions of the positive and negative active material and the bracketed values represent the corresponding ionic concentrations. It is evident that a decrease in the ionic concentrations would result in an increase in the value of E if other quantities remained the same.

The freezing of the electrolyte reduces the mobility of the ions practically to zero. If, then, the ions which are in immediate contact with the surface of the electrodes are discharged, they cannot be replaced by the migration of other ions from the electrolyte and the effect in the region of the electrodes is essentially a decrease in the ionic concentrations. The equation therefore suggests the possibility of increased values of E as was observed after the freezing occurred.

No ready explanation of the reversal of voltage is available unless it be assumed that the variation of solution tension of each electrode with temperature is such that curves representing them would intersect at the temperature at which reversal occurs. Pressure may have had something to do with the voltage variations since the electrometer showed violent fluctuations whenever the frozen electrolyte of the storage cell "ticketed." Ice below the freezing temperature sometimes makes a similar ticking sound.

The genuineness of the reversed voltage was shown by the following observations: The dry cell after showing a steady reversed voltage of about 1.4 volts was removed from the liquid air and in the course of a few minutes, the reversed voltage decreased steadily, passed through zero, and increased to a normal positive value. Secondly, the potentiometer used for simultaneous measurements with the electrometer on the storage cell retained enough sensibility to show that the

[7] Zeitschr. f. Elektrochem. 3: 525. 1897.

potential was reversed at the same time that the electrometer showed a reversed reading.

All of the cells, including the ordinary type of dry cell, the silver chloride cells and the storage cells appeared to be entirely normal after being thawed out. The glass test tube containing the storage cell was not broken.

The experiments in the range 25° to −72° C. answer completely the practical questions which prompted the investigation. The thermodynamic theory as expressed in the Gibbs-Helmholtz equation is accurately confirmed by the measurements on a storage cell. At temperatures down to −170° C. points of theoretical interest were found. These suggest that potential differences of normal value at ordinary temperatures may be greatly magnified at extremely low temperatures when the current is vanishingly small. High atmospheric potentials sometimes observed may have some relation to this effect.

We wish to thank Dr. L. A. Bauer, Director of the Department of Terrestrial Magnetism, for his courtesy in lending us the electrometer and Dr. Mauchly for assistance in taking some of the observations, also Dr. E. Buckingham for valuable suggestions.

ABSTRACTS

GEOLOGY.—*Deposits of manganese ore in Montana, Utah, Oregon, and Washington.* J. T. PARDEE. U. S. Geol. Surv. Bull. No. **725-C.** Pp. 141–243, pls. 4, figs. 11. 1921.

The demand for manganese, created by the World War, caused the development of many deposits in the States mentioned. Those at Phillipsburg and Butte, Montana, which became the most productive in the United States are parts of the quartz veins that carry silver and zinc. They were formed in Tertiary time by the replacement of country rock by manganiferous carbonates and silicates that emanated from intrusive granitic magmas. The superficial parts of the deposits have been oxidized without noteworthy changes in their manganese content.

In Utah deposits of manganese ore related to metalliferous veins are found in several of the mining districts. In the Little Grande district flat lying, lens-like or tabular masses of manganese oxides, found at a certain horizon in the Mesozoic McElmo formation, were deposited originally as carbonate associated with limestone, gypsum and other sediments. In the later Tertiary they were uncovered by erosion, oxidized and locally concentrated into workable bodies.

In the Lake Creek district, Oregon, manganese oxides fill cracks, pores, or other cavities in a Tertiary volcanic tuff. The manganese was deposited by descending solutions, but its origin is obscure. Other deposits formed by

replacement of country rock by carbonate or silicate minerals occur in southwestern and northeastern Oregon.

In Washington, in the Olympic Mountains and the northern part of the Puget Sound region, are uncommon deposits that consist chiefly of bementite a silicate of manganese. Associated with the bementite are quartz, rhodonite, manganocalcite and unidentified oxides of manganese. Hematite forms separate though closely related bodies. Locally the bementite is cut by veinlets of neotocite, a kindred silicate, and in places it contains specks and flakes of native copper. The deposits are thought to be manganiferous marine sediments, greatly altered by regional metamorphism. J. T. P.

GEOLOGY.—*Deposits of chromite in California, Oregon, Washington and Montana.* J. S. DILLER, L. G. WESTGATE and J. T. PARDEE, U. S. Geol. Surv. Bull. No. **725-A.** Pp. 84 with maps, 5 plates and 23 figures.

During the World War it became necessary to determine as closely as possible the chromium resources of the country. It was demonstrated that the United States had reserve deposits adequate to supply a war demand for several years. Now that the war is over the country is conserving its domestic supplies by employing higher grade and cheaper ore from foreign countries.

The first paper "Chromite in the Klamath Mountains, California and Oregon" discusses in detail the occurrence and origin of chromite, and in this respect serves as an introduction to all the papers that follow.

In the Klamath Mountains chromite deposits have three distinct structures, even granular, nodular and banded. The nodular is concretionary and the banded is gneissoid. The even granular deposits are the most abundant and widely distributed in California, Oregon and Washington. The nodular structure occurs in California and Oregon and the banded structure in California and Montana. In California the banded structure is distinctly associated with gneiss; and in Montana it occurs in a remarkable dike of peridotitic rock. J. S. D.

GEOLOGY.—*Geology of the vicinity of Tuxedni Bay, Cook Inlet, Alaska.* FRED H. MOFFIT. U. S. Geol. Surv. Bull. **722-D.** Pp. 7, with geologic map, 1921.

The paper describes the marine sedimentary rocks of a small area on the west side of Cook Inlet where a section of Middle and Upper Jurassic beds is particularly well displayed. These beds comprise a succession of sandstones, arkoses, shales, and conglomerates, derived in large part from a nearby ancient land mass where granitic rocks were abundant, and reach a thickness of possibly 9000 feet. The beds are especially fossiliferous in the lower part and are there characterized by an abundance of plant remains intermingled with the marine invertebrate forms. The jurassic beds are faulted against the volcanic rocks of the Aleutian Range on the west and dip at angles ranging from 10° to 25° south-southeast or toward Cook Inlet.

Petroleum seeps are known in these rocks in the vicinity of Iniskin Bay about 40 miles southwest of Tuxedni Bay but were not seen in the area which is described. F. H. M.

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GENERAL SCIENCE.—*The scientist in the Federal Service.*[1] ALFRED H. BROOKS, Geological Survey.

A presidential address places the auditors completely at the mercy of the speaker, for custom rules that no matter how pitiless his barrage of heresies they may not return his fire. On the other hand, while it is obeying the order "Attention!" the audience is able to examine the enemy's position in critical detail, to note the accuracy of his fire, and to determine the destructive effect of his projectiles. Still a retiring president has the advantage in that he can venture a frontal attack with safety and, if he does not reach his objective or even hold ground temporarily gained, can retire to his trenches of oblivion before a counter attack can be launched.

In this stronghold of Government science it is the part of boldness to discuss the scientists in the Federal service, about which most of you have first-hand information and all of you, no doubt, have fixed convictions. As some measure of defense I shall not omit the time-honored plea of lack of opportunity for exhaustive study, though it may come very ungraciously from one who has been so greatly honored.

The conceptions of the Federal investigator are so varied as to make the task of giving a composite picture of him absolutely hopeless. To the man on the street the Federal scientist is a learned gentleman who, supported by Government bounty, leads in general an easy and indolent life but who on occasion, by some legerdemain, saves a situation. In the industries he is classed by some as a saving angel, by others as a freak, who, because he asks foolish questions and shows a tendency to pry into affairs of others, may be a public pest, one who at long intervals avenges any slight by inflicting a report on the public, written in words that cannot be understood. A few academicians appear to view the Federal scientific corps as composed chiefly of persons of mediocrity who are occupied in routine, propaganda, lobbying, and self-aggrandizement.

[1] Presidential address delivered before the Washington Academy of Sciences, January 10, 1922.

One who would know the Federal scientist must trace him to his lair and must learn his habits while he is running wild on his native heath. His environment is peculiar and must be studied to understand his reaction to it. Are his physical and mental variations from the type of *Homo scientificus* sufficient to justify the setting up of a new species? The biologic phase of the problem is beyond my ken, but I venture the opinion that the Federal scientist does not differ from the average investigator. During a century of evolution this great army of scientists fortunately has not developed a sufficient class consciousness to make it a unit. The strongest critics of Federal science come from within the service, not from without.

The unique intellectual and social atmosphere of Washington, the history and the magnitude of Governmental scientific institutions, and the definite limitations set by law have developed an environment for the Federal scientist quite different from that of the investigator supported by private funds. His field is multifarious in character and continental in dimensions; it includes every branch of science and every industry, and it ministers to the material and educational needs of over a hundred million people. His available resources in funds, however, limit his activities to only part of his field, and his apparently boundless opportunities are closely circumscribed by very definite laws which prescribe both his methods and, to a large extent his objectives.

Detailed knowledge of the conditions of Federal research must needs be based on a close scrutiny of every one of the forty-odd bureaus devoted in whole or in part to scientific inquiry. This scrutiny I have not essayed, for it is beyond the capacity of anyone even had he infinity of time. Moreover, I have a suspicion that such a self-imposed critical inquiry would not be conducive to the long and happy life in Washington that I hope to enjoy. It is fortunate, therefore, that the examination of the affairs of individual bureaus is not essential to learn the general conditions that control Federal research.

The peculiar atmosphere of Washington, a city of Government and little more, has exercised an important influence on Federal science. Here science has been advanced by prescription of law and not by force of tradition or local demand. During a century there has been developed here one of the great scientific centers of the world, and it is a center that is not greatly affected by outside influences. Only during the last two decades have researches other than Governmental found seat at the National capital. Washington's institutions of

higher learning were founded chiefly to meet the needs of her citizens, and their influence on Government science has been negligible. Other scientific centers, such as Paris, Berlin, and London, have grown up under a different environment. In these cities science was fostered by old universities and learned societies long before national research was begun. In consequence, Government science in Europe has been closely coordinated with the great institutions of learning and has been molded by their traditions and personnel. The learned societies of European countries have also had a strong influence on Governmental science. In contrast to this, Federal science in the United States has been developed without academic traditions or without close affiliation with university investigators and it has been little influenced by learned societies. The National Academy of Science, founded half a century after the beginning of Federal research, though charged by law with advisory duties to the Government, has only occasionally been called into consultation. Indeed, before the war the Academy as a body was often out of direct touch and apparently somewhat out of sympathy with scientific work in Washington. Now that it has undertaken the difficult task of coordinating research throughout the land, it has come closer to the Federal investigator. The influence of the National Academy in the past, however, has been very different from that of l'Institut de France and the Royal Society of Great Britain.

Federal science has developed its own traditions, set its own standards, and followed its own self-chosen paths. It may not be denied that this freedom from academic tradition has made for an independence of thought that is not without value. On the other hand, it is not well that the contact between Federal and university science is less close than it was a generation ago. The Federal bureaus are sometimes too prone to regard the universities only as training schools. On the other hand, many of the universities, not clearly understanding the purpose of the Federal service, are overcritical of its results in part, no doubt, because these do not always meet the special needs of the teacher.

Another dominating feature of Washington science is its exclusively professional character. Most Federal investigators devote their entire time to science and find their social life among their professional colleagues. It is science morning, noon, and night, with but few other intellectual interests. In contrast to this, the university scientist divides his time between teaching and research, and the vast majority

of his colleagues are engaged in other intellectual pursuits. Thus the scientific investigator in a university, living in an atmosphere of wide intellectual interests, is usually more scholarly than the investigator in the Federal service. On the other hand, the university scientist has no rivals among his immediate associates, and his results do not always run the gauntlet of stern criticism, as do those of the Federal scientist. The university scientific groups therefore have a tendency to become mutual admiration societies. This tendency and the worship of his disciples among the students sometimes lead the university scientist to become a professional oracle whose dicta may not be denied. Such a mental attitude prevents right thinking, and it is fortunate that the Washington atmosphere is unfavorable to its growth.

If Washington were larger and had more diversified interests, like European capitals, it would include a large number of amateur scientists. I use the term amateur in lieu of a better word to designate the nonprofessional investigator, who is not to be confounded with the dilettante. The amateur brings into science an enthusiasm for his subject which in the professional sometimes becomes dormant. It is unfortunate that he is almost unknown in Washington, for he could do much to vivify science, which may become too much a matter of the day's work to the Federal investigator. Local scientific societies, too, would be benefited by the enthusiasm of the amateur, for these societies are highly specialized, and their meetings too often resemble a council called by some bureau chief. The few amateurs in Washington, though welcomed at these meetings, are not likely to find the atmosphere of professionalism congenial to their aspirations. The university investigator, on the other hand, has the advantage of contact with the amateur as represented by his students.

Most European scientific centers are in large industrial cities, but the industries of Washington are solely those needed to support the population domiciled at the seat of Government. Federal investigators must therefore seek contact with the business world at places away from the scene of their principal activities. Though may of them do so, the scientific service as a whole is isolated from commercial life. Industry sometimes makes the charge that the products of Washington science, because of this isolation, are impractical, meaning thereby that they cannot be used at any given time for commercial profit. Obviously, if a scientific principle is true it cannot be impractical, and it falls to the technician to determine whether it can or cannot be applied to the advantage of industry. This mis-

understanding of the purpose of science is due to lack of clear distinction between the fields of the investigator and of the technician. The investigator establishes a principle of science; the technician utilizes that principle to improve some practice of industry. The confusion of thought is increased because in some fields the investigator may also be the technician and may himself apply to industry the results he obtains from research. Many scientists in the Federal service are acting in this dual capacity. Many inventors and nearly all scientists employed by industry are doing the same thing. However successful and valuable such scientists may be, the fact that the Federal service is largely free from the direct influence of the business world has without question been of great advantage to science and therefore to industry.

Those who are not in touch with Washington life and who know the city chiefly as a political center may hold that the political environment must have an important influence on Federal science. Such an opinion is without basis of fact. Political Washington and scientific Washington are almost as far apart as the poles. One is in constant flux; the other is relatively permanent. One has its strongest ties elsewhere; the other is rooted deep locally. One is typically assertive; the other is deliberative. Political and scientific Washington have, indeed, only one common ground—that of public service. Chiefs of scientific bureaus come into contact with political leaders in setting forth the results, purposes, and needs of their organizations, but the Federal scientific investigator himself is seldom called from his laboratory, and then only because of his special knowledge of some problem of public welfare or policy. These and other occasional contacts with political life are of advantage to the scientist in broadening his outlook on the needs of the people and they should give him a sounder opinion in choosing a field of research than that held by his professional colleague in private life.

The founding of the Coast Survey in 1816 marked the beginning of the Federal scientific service, though some small grants for investigations, chiefly explorations, were made in earlier years. For more than half a century the growth of the service was very slow. Fifty years ago, when the Philosophical Society of Washington was founded, it had only 38 members, and during the succeeding decade, though it remained, except for the Medical Society,[2] the only local scientific

[2] Founded in 1819, with 21 members. The Anthropological Society was organized in 1879, with 28 members.

organization, its membership increased to only about 200. It is probable that during its early years the Philosophical Society included in its membership all the scientists in Washington, and that most of these were in the Government service.

In the time available I have been unable to learn accurately the number of scientists now in the Federal service. There are some forty-odd Government institutions devoted in whole or in part to scientific work, and their employees number many thousands. That only a small number of these should be classed as scientists goes without saying, but the attempt at classification would not only necessitate a close scrutiny of the duties of many individuals, but even then the result reached would be a matter of personal opinion. By actual count in the directories of the Washington Academy of Science, I venture the opinion that the local societies included 600 Federal scientists in 1910 and 770 in 1920. On the other hand, I am informed by Dr. Robert M. Yerkes that in 1919 there was a total of 4,888 scientific and technical employees in the Federal service. It is probably safe to estimate that there are in all a thousand scientific investigators in the Federal service at Washington. Some of the scientific bureaus have much the larger part of their personnel stationed away from Washington. It is therefore estimated that the Federal employees who are making at least some contribution to science number about fifteen hundred.

Though these figures are only approximations, they give a measure of the enormous growth of the scientific service during the last fifty years. This increase has indeed taken place chiefly during the present generation. Before tracing the circumstances leading to the present huge Federal scientific service, I wish to picture Washington as a scientific center at a time antedating its enormous expansion.

The typical scientific bureau of a generation ago consisted of a group of independent investigators studying problems chiefly of their own choice and by their own methods. Organizations then centered on the individual scientist, in contrast to the present practice, by which the problem or the special field determines the administrative unit. Devotion to science was the ideal, often to the exclusion of any thought of public welfare, now accepted as the important duty of Federal investigators. Indeed, there were some who boasted that the results of their research could have no useful purpose. Applied science was then so rudimentary that an investigator was perhaps justified in holding that by advancing knowledge he was fully meeting his obliga-

tion to the public. Nevertheless, nearly all the bureaus, in theory at least, were established to meet some material need, though in practice this need was often lost sight of. Some executives appear to have been willing to authorize researches without too careful a scrutiny of the limitations imposed by law. The chief of a scientific bureau looked upon the allocation of the annual grants of funds and a personal appeal to Congress for increased appropriations as his principal administrative duties and regarded them as disagreeable though necessary interruptions to his own absorbing researches. Appropriations were more often granted because of the personality of the bureau chief than because of a recognized need of scientific inquiry.

By tradition the scientific bureaus were regarded as things apart from the Federal administrative machinery and were subjected to little interference. Though some heads of departments took pride in directing research, most of them paid small heed to scientific bureaus, deeming their work of only academic interest. In those days the scientist, being seldom called into consultation on public affairs, was largely left to his own devices. There was little pressure for his results, for neither industry nor the public at large were vitally concerned with them. A scientist's work room of that day was more like a private study than, as now, a business office. Its tranquillity was seldom disturbed by the rattle of the typewriter or the jingle of the telephone bell. Stenographers were few, and many treatises were laboriously written with pen, to the evident advantage of their diction. Nor was the investigator greatly disturbed by routine matters, the tremendous growth of which has been concomitant both with the development of large organizations and with the increase in the demands of the public for enlightenment on problems of applied science. Fiscal regulations were as abundant then as now, but the marked laxity of their enforcement in many scientific bureaus enabled the investigator to evade those he regarded as irksome. The small personnel in bureaus and even in departments called for few regulations and restrictions. There being no civil-service law, each investigator, in theory at least, was left untrammeled in his choice of assistants. This condition made political appointments possible, and these were by no means unknown in the service.

Many of the investigators were called to the Federal service because of their long recognized standing at the universities, and in general there was a closer affiliation between the scientific service and the institutions of learning than there is now. A considerable per-

centage of the appropriations for research were allotted to university men and the grants being held to be subsidies for research, there was little supervision of their use. This practice followed that of most European countries, which maintained only skeleton governmental scientific institutes and supported research chiefly by allotments to individuals. It may be noted in passing that the exigencies of the war led in part to abandonment of this policy in Europe and resulted in a much greater centralization of research.

A generation ago few universities were able to train specialists, and the young assistants usually had only a general scientific education, though they had a better academic background than those of the present. All expected to serve a long apprenticeship before they launched out as independent investigators.

In early days of Federal science there was not only scant supervision of the investigators but little scrutiny of the results they submitted for publication. The group leader was regarded as competent to determine the validity of his conclusions, and the less experienced assistant was not intrusted with independent investigations. Differences of opinion between scientists were left for them to settle between themselves. Washington science not being held to be of practical value, the public was indifferent whether this or that theory received official sanction. Indeed, there was no such thing as an official dictum, and the originator of a thesis was left to his own devices in defending it in the public arena.

Some exceptions to the above statements should be noted. For example, the Coast Survey, while holding to its long established scientific ideals, was engaged in the very practical work of serving the mariner by charting the shore lines. Again, the work of the Weather Service could not be done with the loose administrative methods that were common to most of the other bureaus. Its stricter organization was no doubt due to its military control.

Living costs in Washington were very low, and the small salaries sufficed to meet the requirements of the simple standards of that day. A family with an income of $2,000 was then better off than one today with $6,000. The corps of investigators was so small that, though officially more independent than now, its members were professionally and socially closer together. A large part of it assembled in the small rooms of the Cosmos Club on Monday nights, where much of the coordination of science took place under the inspiration of a mug of beer and the smoke of a churchwarden pipe. The more formal

discussions were reserved for the Philosophical Society, long the meeting place of the investigators in all sciences who were not too highly specialized to maintain a lively interest in the work of their colleagues.

The atmosphere of Federal science during this early period may be likened to that of a university, at present it resembles that of an industrial establishment. The investigator had little cause to make concessions to the public, either in choice of field or length of time devoted to a problem. To him came conditions favorable to constructive thinking and scholarly presentation. If there were some who yielded to a certain soporific influence in their tranquil environment, their lack of results was offset by the work of those who found in this environment the opportunity for independent effort and great accomplishment.

The great changes wrought in the Federal scientific service during the last generation were accomplished by gradual evolution, but this was greatly accelerated during the present century. Long before, however, the practical applications of science had greatly multiplied. Federal bureaus had been much enlarged, and their scope had been changed. Along with these changes had come closer control of the investigator, together with a clearer recognition of both the spirit and the letter of the law. The change from the individualistic to collective method was indeed fully under way.

The improvement of business methods was most marked after 1906, when the recommendations of the Keep Commission were introduced as far as possible without legislative action. These recommendations fairly revolutionized departmental business methods and were the first decisive step toward eliminating Governmental red tape. The Keep Commission, unlike most others having a similar purpose, was made up entirely of men long experienced in the Federal service and was therefore in a better position to introduce reforms than those who were unfamiliar with the work of the departments.

Collective action by scientific service first crystallized when, because of the needs of the conservation policy, the Federal investigators undertook, by order of President Roosevelt, an immediate census of national resources. Then, for the first time, nearly all branches of Federal science acted with a common purpose and were asked for very definite, practical, and above all quantitative data. This taking account of stock by the trustees of the Nation revealed both the strength and the weakness of Federal research as well as its great

utility to the Nation. One result was the promulgation of stricter rules and more definite instructions and the placing of greater limitations on the freedom of the individual. By far the more important result was the realization by the higher Government officials of the value of science in solving problems of national economics. This realization has ever since been one of the most potent influences in directing Federal research toward problems connected with the public welfare.

Certain conditions that are peculiar to the Federal scientific service have been noted; others will now be mentioned. Those noted have played an important part in the evolution of Governmental research during its century of growth from a single bureau with a few investigators to two score institutions manned by more than a thousand scientists. Far more important to this evolution and indeed an integral part of it is the advance of science itself and a change both in the type of the investigator and in the broadening of his ideals. These changes are worldwide; they are not peculiar to the Federal service. It will be well, therefore, to trace some of the factors involved in the genesis of modern methods and ideals of research.

Three facts stand out clearly: First, science has become a profession—it is no longer an avocation of men engaged mainly in some other calling; second, science has become organized and is not now advanced solely by uncoordinated individual effort; third, science by becoming more exact has become more useful. The transition from the old to the new era has not been synchronous in all sciences. Medicine was a profession long before the modern epoch of science. The work of the astronomer and geodesist was professional, organized, and useful long before that of the naturalist. It will be a matter of opinion as to whether the three facts above set forth are chiefly the cause or the effect of the progress of science. Until the investigator could give his full time to research, progress could be made only by halting steps. On the other hand, until industry found science useful not many professional positions could be open to the investigator. Again, the multiplication of scientific researches to meet the demands of industry called for better organization, and this again has led to the advance of science.

The professional scientist—that is, the scientist who gives his entire time to investigation, is a comparatively new figure. A generation or two ago he hardly existed; anyone who undertook research then had to support himself by teaching or by some occupation re-

mote from science. Even as late as the beginning of this century opportunities to the scientist for professional employment were by no means alluring. In contrast to this, not only are there now thousands who, under public or private auspices, find a means of livelihood in scientific work, but the demand for scientists exceeds the supply. Every branch of investigation offers a career to the earnest student. Scores of examinations are held for positions in the Federal scientific service, and many others are offered by the States and the industries. The student of the present day on choosing his career can weigh carefully the financial as well as the professional opportunities offered. His predecessor had no financial motives, for the best he could expect was only a bare living. In 1846, when Spencer Baird found his salary had reached the dazzling sum of $400 a year, he felt that he could well afford to get married.

In the old days a few great teachers passed their knowledge along to small groups of enthusiastic disciples. Now the universities are annually graduating scores of highly trained specialists, who are by education far better fitted to advance science than those of a generation ago and who after a short apprenticeship can be trusted with independent research. They supply the highly trained and brilliant investigators that are so typical of the present era. On the other hand, some of the products of the graduate schools bear the stamp of being machine made. It sometimes happens that the new investigator is the result of opportunities offered by a university, rather than of an inspiration for a scientific career. A man's exhaustive knowledge of the facts relating to some specialty is no measure of his ability as a constructive thinker. A student may believe he has a call to science when actually what appeals to him is simply the fact that science is an honored profession and a career giving promise of employment. At the time when the profession of the scientist was hardly existent, the investigator was a product of natural selection and must have had that God-given love of his subject for which no training can be substituted. Science was then not a profession but an obsession.

Berzelius is credited with the statement that he would probably be the last man who could know all chemistry, meaning thereby that the science had grown so large that it was becoming beyond the grasp of a single mind. Since his day the naturalist has been supplanted by the botanist, zoologist, and geologist. These have given way to the taxonomist, pathologist, ecologist, glaciologist, and paleontologist, to name only a few of the present subdivisions of the older

professions. The end is not in sight, for as science becomes more exact a still higher degree of specialization is certain. Now a scientist may not even know the meaning of a word that describes the work of a professional colleague.

The tendency of modern scientific education is to produce specialists and not scholars. Advance of science must be effected by specialization, yet the question may be asked whether the investigator who cannot see the forest for the trees is not too great a factor in research. Unfortunately, the specialist is sometimes little more than the collector of dull facts he cannot or will not interpret. In relation to their facts some specialists may be likened to the Indian chief who, because of a certain peculiarity, was called "Man-afraid-of-his-horses." Sweeping generalizations in science are a thing of the past or of the ignorant; yet in spite of the overwhelming number of facts now available, there is perhaps room for a little more boldness in their use.

There is danger at the present rate of accumulation that the scientist may never overtake the continual inpouring of facts. Whenever a research promises to bear the fruit of theory, a possible source of new information may be revealed, and thus interpretation may again be deferred. Nowhere is this more evident than in the Federal service, now perhaps the largest storehouse of scientific facts in the world, including many that are only shopworn. There is a tendency in the service to neglect interpretation. Many Federal investigators could well cease for a time to be collectors of new facts and devote themselves exclusively to an understanding of facts already on file.

When any branch of science has been developed to the point that adequate knowledge of it can no longer be held by an individual but must be distributed through a group of investigators, how are its larger problems to be solved? The answer evidently lies in cooperative effort, without which that branch of science cannot continue to progress. This brings me to the important question of the organization of research.

Through countless centuries science was advanced by the devoted investigator working alone, and it was during this individualistic period that it took root in our own country. As science progressed there was an increase in cooperation, which first took the form of grouping of investigators at universities and museums and the founding of scientific societies and periodicals. Gradually more orderly methods of inquiry and later definite units of research were developed. The evolution of research proceeded from individualistic to cooperative

and finally to organized methods. The organization of research, though long under way and hastened by the war, by no means covers the whole field of science and indeed never can, for much of scientific progress must always be individualistic.

Some of the physical scientists were the first to undertake collective action. The astronomers and geodesists early recognized the necessity of national and international cooperation, and later the meteorologists realized that their work could not be greatly advanced by the individual. Still later men engaged in other physical sciences that require long periods of continuing observation found the value of organization. The natural sciences long lagged behind the exact sciences in this movement, and even today much of their investigation is essentially individualistic. Organization has now gone so far, however, that we have come to think of scientific progress in terms of institutions rather than of individuals.

One grave fault of organized science is that it leaves no place for the amateur, who in the past has done so much useful work. The amateur cannot now hope to compete in the fields occupied by large institutions, with highly organized corps of professional investigators, and in consequence, he is active only in some of the least organized natural sciences. This is unfortunate, for many an amateur is as able an investigator as the highly trained professional and may have an even greater love of science. Science, indeed, originated with the amateur, and until recently he was the chief instrument in its progress. Now, however, he is being crowded out, and soon he may be as extinct as the dodo.

The administration of scientific inquiry in large units originated in the Federal service but has been greatly expanded under private auspices. Whatever faults we may find in these colossal public and private institutions, their all-important work in advancing science cannot be denied. The mere fact of their great multiplication and growth during the last two decades proves that they are meeting a public need. This striking departure from the old methods of research finds no parallel in the history of science, and the origin of its form of administration must be sought in the business world. The government of these institutions, like that of a corporation, includes a board of directors, represented by Congress or by trustees, that approves the general plan of operations but leaves details to an executive who may or may not have a cabinet of advisors. Though the methods of conducting such institutions vary in detail, their basal principle is

essentially autocratic, and their success can be taken as evidence that a wise and benevolent autocracy is a better instrument to advance knowledge than a democracy. Indeed, this form of administering research finds a close parallel in the government of our universities. It appears, therefore, that the centralization of authority in learned institutions, be they educational or investigative, is following a natural law of evolution and has not been arbitrarily superimposed on science, as some believe. Moreover, it is but one manifestation of the very general national tendency toward autocratic administration of both public and private affairs.

As institutional research is the very keynote of modern science and dominates Federal inquiry, it will be well to scrutinize its methods and to consider its merits and demerits. Research institutions differ greatly in their scope and objectives, but the advance of some branch of science is the common aim of all. Their chief differences lie in the field of investigation chosen, and this is determined principally by the terms of their financial support. A few institutions are entirely untrammeled in the selection of problems, but the great majority must give preference to this or that phase of science. The work of the Federal bureaus is very definitely controlled by law, and most of them are compelled to give first heed to industrial problems. There are also private endowments, like those made for medical research, whose principal purpose is to investigate problems of public welfare. Much of the investigation of industrial problems is conducted under private auspices. This work includes that done by institutions whose purpose is to advance the common interests of certain industries, but much the larger part of it is done to gain information that will be of direct profit to those who are furnishing the financial support. In an attempt to classify research institutions, two groups can be recognized. One group will include all institutions whose investigators are made directly for the public benefit; the other will include those whose investigations are made for private profit. Some measure of the public appreciation of science could be had if the ratio were known between the expenditures made for these two classes of investigations. I venture the opinion that the annual disbursements for commercial research far exceed those for public research.

Nearly all research is supported by trust funds, and this fact had led both public and private institutions to establish very definite regulations controlling expenditures. There are, indeed, some who appear to hold that the scientific ideals of an investigator are lowered if he

is called upon to follow good administrative methods. Yet, it is evident that unless expenditures for research are made on sound business principles the confidence of the public will be lost and financial support will fail.

It may not be denied that the recent progress in science has been very largely the work of the modern research institutions. The mere massing of investigators is in itself a benefit, for it produces a certain amount of attrition that tends to remove those bumps of self-esteem which are not unknown among scientists. Moreover, a large institution gives a serious and professional atmosphere to the investigator that is not without great advantages, though, as already pointed out, it has some drawbacks. The more direct benefits to science of organized investigation are self-evident. Many problems can be solved only by the cooperative effort of investigators in several specialized fields. The successful solution of others depends on long-continued and widespread observations that are beyond the power of any individual. Moreover, researches that involve large expenditures should obviously not be dependent on any one person. Another advantage of institutional over scattered investigation is economy of administration.

It is not difficult to recognize weakness in the basal principle of organized research. Its trend is toward uniformity and the subordination of the individual in the interest of the whole. In theory at least each investigator of an institution is but a cog in the great machine of collective effort, yet it is by no means certain that collective is superior to individual mental effort in the production of constructive thought, without which research amounts only to the collection of facts. Therefore, organized research, if it is to advance science, must ever avoid the pitfall of drab uniformity in both effort and result if it is to escape mediocrity. This danger may be avoided by the brilliant executive, who can judge to a nicety just how far individuality may be encouraged without endangering results that are to be attained only by coordination.

Good administration will seek to develop the individual scientist, whatever may be his capacity. In the enunciation of plans for research it is sometimes tacitly assumed that all investigators are of the same general type as the best. Yet most scientific work will always be done by men of average capacity, and good collective results can be achieved only by assigning to each man the task he is best fitted to perform. Humiliating as it may be to our professional pride,

most scientists are and must remain hewers of wood and drawers of water, and a proper organization of research will take due account of this fact.

In former days each investigator advanced science by interpreting facts he had himself ascertained. In contrast to this, there are now many problems whose solution depends on the collection of so large a number of precise facts that the task is far beyond the capacity of the individual observer. This condition has developed the observational type of scientist, a man who is both highly trained and makes an enormous contribution to knowledge and whose very lack of marked mental independence makes him all the more valuable as an observer and recorder. The observational investigator obtains his best opportunities in a closely administered institution. This is also true of the investigators of minor problems of science, whose best results will be achieved under close supervision. On the other hand, the scientist of marked individuality may not obtain the best results under the conditions of organized research. The rare scientific genius, however, needs no special environment to reach his highest development, for he cannot be suppressed.

With this classification of investigators it will be evident that the vast majority will do better work as members of an organization than as individuals, and this alone is a very strong argument for institutional research. Such a conclusion, however, postulates good administration of science, some of the difficulties of which may be considered.

A director of research should have the qualities of the impresario, for the scientist, like the artist, is temperamental and refuses to be cast in the common mold. Though originality of thought must be cultivated in every scientific institution, there is a constant danger of its overproduction. A scientist may apply his originality not only to research but also to financial and routine matters, at a serious loss of efficiency. It is indeed astounding how many unnecessary difficulties a brilliant investigator can create by ignoring simple business methods.

Many scientists have for years groaned under the Federal system of accounting, without ever understanding its basal principle. Government disbursement is, indeed, complex and growing needlessly more so, but difficulties come chiefly to executives and professional accountants; the average investigator meets only its simplest forms. The days are past when the efficiency of a Federal bureau was gaged by the perfection of its vouchers, and although disbursements must

comply with the law, they are not now held to be an end but only a means to an end.

Many a scientist, however, still believes that he has been singled out as of proved dishonesty because some official has directed his attention to an infraction of the law. He does not see either that close regulation of Federal disbursements aggregating billions of dollars is necessary or that the legal safeguards must apply to small as well as to large transactions. Indeed, many scientists are ignorant of the principle of all fiscal regulations, namely, that the law holds all Government moneys to be trust funds. The law also provides that every trustee must be able at all times to submit documentary proof that he has not stolen the funds in his custodianship. Therefore, upon every Federal employee who handles public funds or involves the Government in liabilities rests the burden of proof that his trusteeship has been honestly administered. Evidently all purchases are governed by the same principle, and the purpose of competitive bids is to prevent dishonest connivance between the seller and the Government agent.

Certain scientists regard the limitations placed on their fiscal operations as a personal insult and an attempt by a bureau chief to assert his authority. To them fiscal regulations have no purpose except to hamper research, and they never come to understand that a regulation is nothing but an interpretation of the law. If these men would master the basal principle of Federal accounting and the simple methods they are called upon to use they could command more time for their own work.

The fiscal regulations are particularly irksome to those who remember the time when they were but loosely enforced in the scientific bureaus. In those good old days scientists and sometimes even bureau chiefs gloried in successful attempts to evade the law, or in what may be termed "putting one over." Such practices resulted only in more stringent laws and interpretations. It is quite likely that Federal auditors have blacklisted individuals and even certain bureaus that have been found attempting to evade the law, and that their vouchers receive a specially searching scrutiny.

Yet there is certainly room for improvement in the laws governing Federal disbursements, as for example, in the restriction placed on the use of automobiles. It seems beyond human knowledge to understand why the use of horse-drawn vehicles is unlimited, while that of automobiles is closely restricted. It is as if Federal trans-

portation should be effected only by stage coach and canal boat instead of by railroad. But the origin of this anachronism is clearly traceable to some abuse in the employment of official automobiles for private use. This is an example of an ill-advised law enacted because of a breach of trust by some individual or small number of individuals.

It is also hard to understand why the Federal scientist should be penalized when traveling on official business by not being reimbursed for a part of his expenses. It would be equally logical to force him to contribute toward the cost of renting or heating his laboratory. The law limiting the amount paid for subsistence was passed because a former commission indirectly augmented the salaries of its professional corps by allowing a large per diem for subsistence, irrespective of whether the men were working at the home office or in the field. Unfortunately, Congress, when it uncovers such an exceptional abuse, is wont to believe that the abuse is general and enacts sweeping statutes, whose real purpose is to rectify the action of a few.

Although there is a growing tendency to increase the restrictions on Federal disbursements, yet we can comfort ourselves with the thought that both efficiency and economy are now included in the war cry. Probably the modification of less than a dozen statutes would suffice to do away with the obstacles that prevent Government work being carried on efficiently and therefore economically. It is a curious fact that most reformers have yet to discover that much of the proverbial Government red tape has been eliminated and that much of what is left is imposed by law and not by tradition or executive order.

A private institution of research supported by trust funds is also under the obligation to provide definite regulations to control expenditures. These regulations can, however, be framed to meet its special needs for it is not, like a Federal bureau, a very small part of a colossal organization charged with the disbursement of huge trust funds. The bureau chief must enforce the law as he finds it, even though he knows full well that it decreases the efficiency of his own organization.

I take it that all will agree that the first test of good administration of science will lie in the choice of investigators to do the work. In this matter the endowed institutions have a great advantage over those of the Government, in being able, in a measure at least, to adjust their salaries to meet competition in the commercial world. On the other hand, some will be attracted to the Federal service because

of the opportunities that it gives of being of direct human benefit. With these the call of science is no stronger than the call to aid their fellowman.

Positions in newly established institutions are in general eagerly sought, because of their promise to yield opportunities in untrodden fields. As a consequence the scientific personnel of such institutions will be of the highest type. These new organizations, moreover, are unhampered by the inclusion of investigators who have not fulfilled the promise of their earlier years. Unfortunately, the psychologist has not yet given us a formula by which the hundredth man can be definitely selected. Moreover, even though he may be found, a transfer to a new environment may produce an atrophy of his mind, for a scientist of a certain type seems to require the stimulus of obstacles to do his best work, and the easier his path the less productive his brain.

If no errors are made in the choice of investigators, the very independence of thought that characterizes the best investigators will in itself make difficulties for the executive head of an institution. He must foster individuality, yet he must mold the whole to produce collective results. The most valuable investigator may be the very one who most strongly resents any interference with his personal activities. Even Federal scientists, sometimes pictured as a set of brow-beaten investigators who dare not call their souls their own, are in truth most strongly independent. Their faults and difficulties have been clearly portrayed, but little has been said of their duties and responsibilities.

The scientist who joins the Federal service assumes other very definite obligations than those expressed in his oath of office emphasizing the defense of the constitution. Generations of scientists may pass who are never called upon to defend the constitution, but the responsibility to obey both the spirit and the letter of the law is always with them. Even more binding is the moral obligation to advance the interests of the people under whose bounty they are working. This implies, first and foremost, that they work for the truth and nothing but the truth, for without this ideal both pure science and applied science are but shams. These obligations have been fully lived up to by most Federal investigators. A few attempts have been made to gain popularity by premature announcements of assumed epoch-making discoveries, but these, like other short circuits, led to quick disaster. Some Federal investigators feel their responsibilities so

keenly as to err on the other extreme and become lax in the duty of giving any returns to the public.

The obligation imposed on the Federal scientist often runs counter to his personal ambitions. He chafes under a condition, imposed by law or by public need, forcing him to abandon some favorite field of research for one of less interest. It makes his unsought task no easier if, as sometimes happens, a colleague with only a rudimentary conception of public duty implies that he has abandoned pure science for some more popular field.

Every administrator of research finds his chief problem in the control of his scientific personnel. To some this problem appears most simple and involves only the giving of financial support to the master mind and then allowing it to wander whither it will. Such a course, however, will not lead to the solution of a cooperative problem. Moreover, the master mind, if left to its own devices, may wander entirely off the premises. The task of the executive is to harmonize the work of a group of strongly individualistic investigators, whose tendency is centrifugal rather than centripetal. Success will be achieved by a proper balance between individualistic and cooperative inquiry. There is the danger, on the one hand, of discouraging originality of thought, and on the other, of failing to maintain the necessary unity of purpose.

The executive in the Federal scientific service stands between the horns of a dilemma. If his bureau is not so organized as to provide very definite control of the work of the individual investigator he may fail to achieve the results demanded by the terms of his grants. If his organization is such that it does not give full play to constructive thought by the individual investigator he will accomplish little to advance his science. He must constantly strive to have his administrative machinery sufficiently elastic to develop the best mental work possible by each of his scientific staff. At the same time he must not ignore his obligation to give results to the public. Some investigators need constant spurring to obtain results; others need restraint, for their productions come so fast as to raise the suspicion that they may not be sound. Although the premature announcement of conclusions meets with quick punishment, the procrastinator often receives undue credit among his colleagues from the very fact that he has failed to make the evidence of his attainments public. Indeed, he often hampers the advance of science by occupying a field to the exclusion of others and by discouraging financial support for the organization

to which he belongs. If he is in the Federal service, his chief bears the moral responsibility for the expenditure of public funds on investigations that have come to naught. Not all investigators sense the moral responsibility for a return from researches supported by trust funds. The exceptions do not appear to realize that the final justification of any project is measured only the results achieved.

There will be differences of opinion as to whether scientific work in this or that field is yielding results commensurate with the outlay made for it, but the value of the great mass product of Federal science cannot be denied. In this day, when all Government expenditures are being closely scrutinized, the scientific bureaus can calmly welcome the fiercest light of publicity. I am sure that the unprejudiced examiner of public business will concede that the product of Government science is worth more than it cost and that no private corporation could obtain equal returns from the same expenditure. This fact in itself is proof of the high grade of the personnel in the scientific service. The thousand men engaged in this work include men of various types, and if it becomes necessary to record the faults of a few of them, these few are the exceptions—their faults do not characterize the group as a whole.

The delay in making public the results of research is one of the evils of the Federal service, but for this the scientist and the bureau are only in part responsible. Yet a considerable part of the blame rests upon the scientist himself, and his delinquencies may be due to his lack of certain mental, not to say moral qualities. The delinquents are of several types, and they include the investigator with a brilliant mind, which, however, is so undisciplined that it cannot be made to formulate conclusions. A very small percentage of the delays are chargeable to lack of a sense of moral obligation. This lack is shown by the dilettante type of investigator, who flits from one problem to another and seems to think that he fulfills all obligations if he simply remains on the Government payroll. Most often, however, the procrastinator is the hardest working of men, and his unwillingness to put forth conclusions is due to his fear of omitting some detail or failing to fully test some theory. We must respect such a seeker of truth, yet a part of his fault may lie in a certain conceit which induces him to believe that his results are so epoch-making that he trembles for the consequences to the Nation if they should be announced prematurely. It sometimes happens that before he has set the keystone of the arch that forms his *magnum opus* its founda-

tions have been undermined by some colleague, and the whole structure tumbles, becoming little more than a vast collection of misinterpreted facts. There is indeed always the danger that if the investigator withholds the results of an inquiry too long he will become "stale" on it before he has formulated his conclusions. Then the elaborate report may be only a jumble of facts whose interpretation must be left to others. It may even happen that the results of years of scientific research are entirely lost by the death of a dilatory scientist. It is a matter of record that every great scientist leaves a series of milestones that mark his progress, and when he attains the goal he need do little more than prepare a final summation of what has already been fully published to the world. Therefore, if no results from an elaborate research are announced the executive has a right to the suspicion that there will be none. To him then comes the important decision whether to continue expenditures on the project or to write it off in the profit and loss account. If he continues the work and nothing comes of it he has been unfaithful to his trust; if he stops the work there is always the danger that science and the people may be the loser.

Another problem in personnel is presented by the scientist who is as quick as a hair trigger in publication. He boldly rushes into publicity where the more experienced investigator fears to tread and, though he may be endowed with a certain superficial brilliancy, he is too impatient to carry his researches through to the end of establishing conclusions. His contributions may be likened to skyrockets—they illuminate the scientific landscape for a moment only to fall to earth and leave us in darkness. Such men are sometimes the pests of scientific literature, and some of them bury the results of their unfinished researches in huge, soon-forgotten tombs. If they gain admission to Government publications they may temporarily win undeserved reputations by the very size and elaborateness of their memoirs, though these may be the work of the pen rather than of the brain.

The secret of good administration in science, as in other affairs, is to make the best use of the personnel available. Experience shows that it is possible to guide the able investigator, but he cannot be forced to follow set paths. He has, moreover, the tactical advantage of not being "enlisted for the duration of the war," and he can probably obtain a letter livelihood in commercial work. Some of the most obstreperous members of the Federal scientific corps possess qualities that are most valuable to science and to the public service. If the

great majority of the Federal scientists were not always ready to do more than their full share in meeting their obligations to the public, the task of administering Government science would truly be hopeless. An executive who is taken into the public service from the business world and who has adopted the modern standards of efficiency would see no difficulties in administering research, for he would meet them by riding rough-shod over all scientists. Research, would be so organized that birds who can sing and won't sing would be made to sing. Every cog in the administrative machine would be compelled to do its proper work or make way for another. This plan does not make any allowance for the individual, nor for the fact that the brain cannot be forced to originate—that it cannot be thrown into gear by moving a lever. You cannot feed brains into a hopper and, by applying a sufficient number of mental impacts to your machine, produce a smooth-running new thought at the outlet.

Though organization and personnel are of fundamental importance to every research institution, yet the real efficiency of any such institution in advancing science will be determined largely by its choice of fields. The sternest critics of Federal bureaus have dwelt on errors in the selection of problems. Many of these critics hold that the preference for economic problems indicates both a lack of thoroughness in research and an abasement of scientific ideals. It is strange that no such criticisms have been made of the institutes of medical research, though their avowed purpose, like that of the Federal scientific bureaus, is to better the welfare of mankind. The high sources of some of these criticisms justify their consideration.

Every constructive criticism of the service should be welcomed, if only because it is well to see ourselves as others see us, but before its true value can be gaged it must receive proper correction for the personal equation of the critic. Most of those who enumerate the faults of scientific bureaus fail to distinguish between the faults due to law and those due to policy. Every Federal scientist recognizes the need for certain changes in law, but he is powerless to bring them about.

Meanwhile Federal scientists should not ignore the ominous signs that the skeleton in the closet of Federal research may at any time be exposed to public view—that the deceptive Government investigator may be unmasked. Already some critics have intimated that Federal science, though it may delude unthinking people, is not true research but something else not yet well defined. Classifications of research

institutions have also been made in which all Federal investigations are ignored. To the slur implied by this omission no reply is possible and the thousand or more Government scientists can but bow their heads in shame in the presence of those to whom the great light has come.

Though outwardly the Government investigators may remain calm in the face of the occasional storm of criticism that blows about their heads, yet often they find some note that harmonizes with their own feelings. Is there anyone in the rank and file of Federal scientists who has not at least one pet grievance and is not convinced that, if he were in charge of certain work, he could soon abolish some crying evil? Such grievances, though various, are most often, for lack of better definition, charged to bureaucracy. The wrong may have been committed by some cold-blooded auditor who, in enforcing the law, has blocked the progress of science by eliminating an item from an expense account. An investigator whose work is far in arrears may have found his chief very unsympathetic. It may be that the publication of some monumental treatise has been postponed for lack of funds. Again, official indorsement may have been denied for some pet hypothesis that, if only it prove true, will revolutionize science. It may be that a lack of funds forces an investigator out of his favorite field. The fault may be in a law by which the work of a bureau is made to include some activities that an investigator believes to lie outside of its proper scope.

The charge frequently made that the scientific service is employed chiefly on problems whose solution will directly contribute to the welfare of the Nation may not be denied. If this were not true the bureau chief would be a derelict in his duties to the public as well as a violator of law. The command that research be directed toward material ends is incorporated in the organic or appropriation acts of nearly every Federal scientific bureau.[3] For example, both the Coast Survey and the Naval Observatory owe their origin to the demands of the merchant marine and the Navy. The Geological Survey was established primarily to help to develop the country's mineral wealth and to evaluate the public domain. The needs of industry were met by the establishment of the Bureau of Standards

[3] The Bureau of American Ethnology appears to be an exception. The appropriation for the National Museum, made originally for the custodianship of Government property, can be said to have for its purpose the education of the people. The Smithsonian Institution is supported by a private endowment and is therefore an exception among Government institutions.

and the Bureau of Mines Again, the demands of the farmers led to the setting up of scientific work in the Department of Agriculture. The value of a better knowledge of commercial geography, because of our expanding foreign trade, has recently been recognized in the policy of the Government.

There is a tendency to give the entire credit for the establishment of this or that scientific bureau to the genius and persistency of one man. Thus, Hassler is rightly associated with the founding of both the Coast Survey and the Naval Observatory, Ellsworth with the improvement of agriculture by Federal agencies, and King and Powell with the organization of Federal geologic surveys. Many other examples of the influence of certain men on the founding of the younger bureaus could be cited. Government science owes much to the broad concepts of these pioneers, but it must not be overlooked that they would have been powerless to accomplish their work if the conditions had not been favorable. Recognition by the Federal Government of the need of Government scientific investigation in any particular field is based on certain premises First, the science must have made sufficient progress to give assurance that the results of the work to be done will in some way promote the general welfare. It must therefore have passed beyond the realm of speculation, and its results must be concrete rather than abstract. Second, the industry it is expected to benefit must be of enough national importance to create a wide demand for the results of the research.

In an absolute monarchy this or that investigation may be ordered for the mere sake of advancing knowledge, but in a representative government the argument for research must include very definite evidence that the people will be directly benefited by it. Once an investigation is established and concrete and practical results are obtained, plans for extending the research to more basal problems often receive support.

The sharp distinction attempted by some between investigations of purely academic problems, on the one hand, and investigations of problems of industrial and public welfare, on the other, needs consideration. I hold that this arbitrary division of scientific investigation has caused much confusion of thought. It is, indeed, unfortunate that no better designations have been found for these fields of inquiry than "pure" and "applied." If one is "pure" it would seem that the other must be "impure." If, again, research that is directed toward aiding industry is called "practical," as it has been, it would seem to

follow that all other science is impractical, a conclusion that will hardly satisfy its devotees. In making such a distinction it should be remembered that there is often a quick transfer of the results of pure science to the category of applied science. A scientific product so "pure" that it will stand the most searching "tubercular test" may be snatched for "applied science" before it has been fairly delivered at the doorstep of the consumer. If the exact meaning of the words is retained, applied science, or, indeed, we should say science applied to industry, must be restricted to the work of the technician and inventor who uses a scientific principle for some practical purpose. The principle may be the result of an inquiry either by an investigator whose only motive was to determine the law itself or by one who foresaw its possible practical use. The condition remains the same whether it is the application of the simpler laws of mechanics in the making of the formerly very useful device called a beer stopper or the application of the laws of physics in the building of a tide-predicting machine.

The difficulty of accurately defining pure science as distinct from applied science leads to the suspicion that there is really no basal difference between the two. No one can doubt the "purity" of inquiries into the laws of terrestrial magnetism, yet their practical value to the surveyor and the navigator cannot be questioned. A geologic map is clearly a contribution to pure science, yet who can foresee to what base use it may be put by the prospector? The results of any given research may be classified as to the validity of the conclusions, as to the value of the results to science, as to the ability of the investigator, and as to the thoroughness of the methods employed; but the scientist's motive for the research affords no logical basis for assigning it either to pure or to applied science.

Illogical as these terms may be, however, a lack of originality to invent new ones forces me to use them. In the commonly accepted phraseology, then, the term pure science includes nearly all university research and that of many endowed scientific institutions, and the term applied science includes researches that are avowedly devoted to industry supported by private funds, and also those of the great medical research institutions. The Federal scientific service is, however, the great stronghold of applied science, though it includes some researches, like those of the Smithsonian Institution, that must be classed as pure science.

Kelvin has said that "no great law in natural philosophy has been

discovered for its practical application." Yet he himself was one of the great users of science in practical affairs. Notwithstanding opinions to the contrary, there is almost overwhelming evidence that science has gained by its very marked drift toward material problems. It is certain that the vast sums now devoted to research are available because of the demands of industry. If investigations made for material ends do not advance science, we must grant that its progress is due to less than 10 per cent of present-day research.

It is sometimes intimated that the investigator working in economical fields has lower ideals than one who is employed in pure science. There is, indeed, no definite measure of man's ideal, but perhaps the best measure can be found in the unselfishness of his purpose. The scientist who is employed on a self-chosen problem and who is perhaps working in an ideal environment and with adequate financial support does not necessarily have higher ideals than one whose path lies in a less interesting field or one whose ultimate purpose is to improve the conditions of human life. The average investigator of the Federal service makes little parade of the motive of science for science's sake, yet his love of truth is no less than that of his colleague from the university of other endowed institution.

Another fallacy is the contention that pure science as contrasted with applied science leads to more thorough investigations. Yet the master mind will ultimately reach the basal principles of his problem, whether his researches are made in pure or in applied science. Any difference between the work of the investigations in these two fields is, indeed, solely a matter of mental equipment and bears no fixed relation to the line of approach. Many scientists have not the brain power to delve far below the surface and hence must remain cataloguers of facts who here and there reach a valuable general deduction. Some of this class, indeed, find a temporary abode in the realm of speculation, and the more academic their problem the longer they remain in that realm. If, however, their speculations relate to fields that touch human needs their sojourn in that high yet misty atmosphere is likely to be quickly terminated. Some materially minded man, mistaking their chaff for wheat, may make a practical application of some high-spun theory, with resulting disaster. No surer test of the validity of many a scientific hypothesis may be found than its practical application. Therefore, the scientist who is working with an eye to practical results is likely to weight his evidence more carefully than the one whose pronouncements are of purely academic

interest. In other words, if an investigator has the necessary brain power the fact that his researches are directed toward the solution of a practical problem will not prevent his reaching the very fundamentals. Moreover, the large majority of investigators are likely to be more accurate in their inquiries if the results are to be subjected to the acid test of industrial use.

Under the stimulus of industry every crumb of scientific knowledge is seized with avidity, and there is always danger of premature announcement of results. An investigator more anxious to obtain the plaudits of the public than to test the soundness of a theory may yield to this temptation. This has happened in the Federal service with the connivance of some bureau that hoped to receive support because of spectacular announcements rather than because of thorough work. The evil cures itself, for the punishment will be quick and drastic.

Some critics hold that the ideals of the investigator will be lower if his research is directed toward the solution of industrial problems. These critics are strangers to the inspiration that comes from hope of rendering service to the people. Most great inventors must have felt the same stimulus, even though they are generally credited with only the motive of gain. The sympathy of the people gives an inspiration to the investigator which is not exceeded by the expectation of advancing scientific knowledge alone.

"Science for science's sake" is sometimes used to express the highest ideal of the investigator. The essence of this borrowed phrase is simply love of truth, to which every scientist must always be loyal. Scientific ideals are not in danger because research may be directed to supplying the material needs of the Nation. The real danger lies in the investigator who, while parading his love of science, in reality makes this only secondary to his desire for self-aggrandizement.

It is a measure of our high scientific standards that some of the best opportunities for research come to those by whom they are well deserved, but the greater number of scientists must "carry on" under conditions as they find them, and perhaps even greater honor than that accorded to the favored ones is due to him who goes forward on a path strewn with difficulties. Science is not commercialized when it is used for practical ends; only when the investigator is working principally for his own profit. Yet we should not judge harshly those who have been driven by threatened bankruptcy to leave their laboratories and their professorial chairs for commercial life. This course is not

the fault of the individual; it is the result of the failure of the people to appreciate the true value of the work of the investigator.

The attempt is sometimes made to classify scientists not by their achievements but by their environment. The result is as artificial as to classify them by the number of capital letters they have the right to print after their names. Though scientific leaders have generally received recognition by well-earned honors, the tuft hunter is not unknown even among scientists. An honor conferred on such a one evidently proves nothing but success achieved in a very specialized field. This condition is unavoidable, and it in no sense detracts from the dignity of the honor rolls of learned institutions. It gives, however, an indication of the danger of any measure of merit except that of accomplishment.

The greatest scientists come from those whose love of truth impels them to make every necessary sacrifice to advance knowledge, and if by so doing they also better the condition of mankind they deserve all the more honor. Their devotion to science is too apparent to need shouting from the housetops, nor does its purity require the stamp of any registered brand. Such investigators evaluate the work of their colleagues by results and not by hair-splitting distinctions between pure and applied science. They know nothing about that rarified atmosphere that is so pure that it might be deadly to the Federal scientist if by accident he should be permitted to breathe it.

The Federal bureau chief who devotes the resources over which he has control to some urgent problem of public welfare is sometimes charged with truckling to popularity. This charge is occasionally just, but there are enough examples of the unpopular side of a controversy being taken solely from motives of public duty to prove that it is not a general rule. Indeed, many an executive has with deep regret turned from some important and attractive field of research solely because of a conscientious interpretation of the law.

The resources of the Federal bureaus, though considerable in the aggregate, are always inadequate to cover their fields of science. A choice must therefore be made among many problems, and this choice will be guided by the wants of the people. The selection of the field of inquiry by a Federal executive may be likened to that made by the explorer of a new land. In the interest of broad knowledge and by personal preference the explorer may first essay the precipitous and difficult slopes of its highest peak. He may hold that the wide view obtained from the summit will so greatly advance knowledge as

to fully justify the time and money necessary for the project. On the other hand, he may reflect that the attempt to scale the peak has no assurance of success until the foothills have been searched out and routes of approach discovered. Then, again, he may remember that his first object is to discover regions suitable for the abode of men. Because of these considerations he must decide to begin his exploration in areas of lesser relief and thus make his work of immediate benefit to the people. Just so the Federal investigator, in the performance of his public duty, must give preference to those fields of research that directly benefit the mass of the people he serves.

I have invited your attention to some of the adverse opinions on the policies of Federal research. Each of you will accept or reject them according to his own lights, yet they deserve earnest consideration by every American scientist. If those in the Federal service are not doing their share to advance science they are not living up to their trust. If those out of the service are convinced of this they too have a public duty to perform. Be this as it may, there is another and very serious aspect of the matter. The whole spirit of American science today is one of cooperation. To promote this spirit the time of many eminent men and considerable funds are being expended. If the large body of investigators in the Federal service are unjustly charged with lower ideals than those in private employment a serious schism will develop in American science that cannot be healed by the appointment of committees.

Though we may agree that the general policy of the scientific service is sound, yet we must admit that there are tendencies that should be checked. One of these is the drift toward technology. Many Federal institutions are charged by law with both scientific and technologic investigations, and the two fields cannot always be definitely separated. Yet there is danger that researches into the fundamental laws of science be neglected, though these laws must obviously be learned before they can be applied to industry. Nearly all Federal investigators are pressed for results, and consequently they have a natural tendency to give preference to the smaller problems—those that do not consume too much time. Some of the problems thus chosen might well be left to industry, and the funds devoted to searching out the more fundamental principles.

Perhaps the most crying evil in the service is the endeavor to accomplish too much. Our vast area and our complex industries lead to demands that cannot be met with the resources available. The

attempt to cover too wide a field is the result in part of general policy and in part of the ambitions of the investigator. The result of this attempt is that most of the conscientious workers in the Federal service are overburdened. It is clear that nearly every bureau is undermanned for the tasks it undertakes, especially now that so many of the investigators are newcomers. Much of the work is carried forward by the wheel-horse investigator, whose progress is slow and steady and whose load is constantly increasing, sometimes almost to the breaking point. The more brilliant but often eccentric scientist, riding on top of the load, may be employed chiefly in pyrotechnic displays which, dazzling as they may be, do little to carry forward the burden. It is the wheel-horse scientist who needs relief and more opportunity for constructive thought.

It is often forgotten that the scientist should disseminate as well as increase human knowledge, and if his work to this end is measured by results the American man of science has much neglected his duty. I venture the opinion that there is today relatively less popular knowledge of science and less interest in its methods and achievements than there was a generation ago. The Constitution provided that Congress could advance science by enacting laws for granting patents. This was one hundred and thirty-four years ago, when the only concept of scientific investigation was afforded by the work of the inventor. Yet to a large part of our people research and invention are still synonymous terms, and even among those who are well educated there are many who conceive of research as a kind of hocus-pocus that results in brilliant discovery. A scientific genius, they believe, retires to his laboratory with pad and pencil, to emerge twenty-four hours later hungry but triumphant. Much periodical literature that is ostensibly devoted to disseminating science among the people is given over to descriptions of inventions, chiefly of the simplest type, with no discussion of the principles involved.

The lack of popular knowledge of science is, I hold, directly due to the form in which science is presented. It has been found easier to multiply specialized technical vocabularies than to express results in clear and precise English. We have followed too blindly the German scientists, who with all their thoroughness seldom elucidate principles either clearly or forcibly. They have invented that wonderful word "allgemeinwissenschaftlichverstandlichkeit," though few of them have had occasion to use it. The German has the advantage of a language that may be written in an accepted form and yet be com-

paratively incomprehensible, and this without even recourse to a specially invented jargon. Some American investigators seem to agree with one school of German thought, holding that science is for the chosen few and that the mass of the people must take scientific orders rather than explanations. Indeed, we are not altogether free from scientific snobbery, by which the results of research are held to be sacred to the elect.

Perhaps the greatest need of the average American scientist of the present day is to learn to write clear English. How can we hope that the people will respect and support science if we give them its message in words that they cannot understand? The seriousness of the situation is brought home by the fact that scientists themselves often cannot understand the expositions of their colleagues. If American investigators are to abandon the use of our common tongue, we must needs invent a scientific Esperanto. What we may call the stenography of science, expressed by the vocabulary of the specialist, the formula of the chemist, and the equations of the mathematician, is necessary, yet the masters of scientific exposition have been able to present their conclusions without too great use of these mysterious symbols. It is not to be denied that the progress of science has made it necessary to coin words for new facts and new theories. The invention of new words has not ended there, however, for they often express only old facts and old ideas. Scientific writings are also made needlessly obscure by refinements in the use of technical words that are in no way essential to the main thesis. Moreover, long and unusual words are often preferred to shorter words that are in more common use. Some scientists appear to believe that unless their writings are ponderous they will lose standing among their colleagues. As a consequence, when a scientific treatise is written in such form as to be understood by the average educated man, the public exclaims at the marvel.

Someone has described sociology as a science which tells us what we already know in words we cannot understand. Even though this may be a slander, much scientific writing is open to the same criticism. Scientific treatises so camouflaged with technical phraseology as to obscure their paucity of ideas are not unknown. It is sometimes forgotten that clear writing is the offspring of clear thinking. Those who doubt that science can be presented in both elegant and clear diction should turn to the treatises by the French, and that this is not a matter of language is shown by some scholarly expositions by the British.

It is a striking fact that relatively few popular scientific works are now being written in this country. In a recent list prepared by a committee of this Academy a large percentage of the books were written by Englishmen. In scientific textbooks America probably leads—certainly in numbers. Most of these books, however, are written for the pedant, and no matter how valuable they may be for his use they are not likely to awaken popular interest in the subject treated. Indeed, some of them appear to have been prepared for the market rather than because the author had any message to convey.

The Federal scientist, because of his direct responsibility to the people, deserves the most censure for the faults of presentation. Many bureaus have, indeed, prepared very good popular treatises on some applications of science, but most of their other publications are couched in technical language that is incomprehensible to all but the specialists. Some of their results, with the aid of the newspapers, have been reduced to popular form, but most of these "translations," as we may call them, are written for the unthinking man, who is generally willing to take his science on faith and therefore meeds no expositions. To meet his supposed needs science is "melodramatized," and startling discoveries are emphasized at the expense of presenting principles. The form of the "stories" in the sensational press is followed more often than that of the expositions of art, history, and literature found in our best periodicals. What is needed is the presentation of science in a form comprehensible to the educated and thinking man, and this work must needs be done by the investigator himself. The other important work of interpreting science for the mass of the people can best be left to those who have special talent for the task. It should be said for the Federal investigator that for most of his work he is not always given the time necessary for clear writing. He therefore has recourse to scientific jargon and sometimes, indeed, leaves to the devoted bureau editor the correction of his faults of diction.

Research may be popularized not only by properly presenting its results, but by informing the public of its purpose and methods; and in this too there is room for much improvement. The investigator who runs true to type avoids rather than courts publicity; he asks nothing more than to be left to solve his own problems. This desire has become almost a mania in many scientists, both to their own detriment and to that of the public. Publicity has therefore been left to the occasional worker who is far from willing to hide his light under a bushel. The public, almost entirely ignored by the average

scientist, finds this exceptional type, usually not a difficult task, and takes him at his own valuation. In so doing it may forget that the efficiency of a steam engine cannot be gaged by the volume of sound produced by its whistle. If science is permitted to reach the average man principally through the agency of a few self-selected mouthpieces, investigators have only themselves to blame. There is no higher mission than the dissemination of science among the people, and those who undertake it with no thought of self-glorification and often at the expense of their own researches certainly deserve the highest praise.

A more amusing and perhaps less valuable type is the restless scientist. He usually devotes far more time to exposition than to origination. If the activities of the restless scientist take the form of publication, they may appear with the noise and regularity of the projectiles from a machine gun. We should remember, however, that the destructive effect of an automatic weapon is due to volume of fire rather than to accuracy of aim; also that its projectiles are machine made and of light weight. At other times the restless scientist manifests himself by close attention to public meetings. No convention, society, or committee is complete without him, and if not on the platform he is at least on a front seat. His voice is heard in favor of the most popular reform of the day, and he is critical of his colleagues who do not join the chorus.

We marvel at the publicity scientist, who often seems to be bearing the weight of the Nation on his shoulders, but we must acknowledge that he may be a valuable member of the body politic. Though he has usually abandoned research, yet he stirs up his less progressive colleagues, and, above all, he keeps science in the public eye. Some of these men are doing most valuable work, and it is not for those who hold themselves aloof from the public to take them to task. He who sacrifices his own scientific career with the purpose of bringing to the people better knowledge of the results, needs, and methods of science merits the highest praise and should have the full support of every scientist. Adverse criticism must be reserved for him whose publicity work is largely devoted to self-advertising.

The working corps of publicity scientists is recruited in part from the Federal service, but I believe the Federal recruits are outnumbered by those from other sources. Recent legislative restrictions have rather discouraged the activities of the familiar type of traveling scientist of the Federal service, who was most often found elsewhere than in his own laboratory.

There is an old Washington story worth recording, though probably it is familiar to you all. A visitor, much impressed with the large number of specialists included in the membership of a local club, expressed his enthusiasm by exclaiming, "You can ask no question in the Cosmos Club but you will find the man who will give the answer." One of his auditors, long resident in the city, remarked "Yes, and I know the man." He had reference to one of a type that may be designated as the "professional prominent scientist." This type, though not unknown elsewhere, was at one time conspicuous in Washington and was the popular authority on all scientific questions. A new problem was the signal for at least a half-column interview, in which a final dictum was pronounced. Though he sometimes failed to impress his colleagues with the profundity of his knowledge, the public was ever ready to worship at his shrine. His evolution, a perfectly natural one, was due to the craving of the man on the street for an understanding of something of science, a craving satisfied by but few investigators. He served a valuable purpose, and the popularizing of science has certainly lost ground since the position of scientist laureate has become vacant.

The first gun at Liége, inaugurating the upheaval that was destined to shake the foundations of civilization, opened a new field for science, which the coming of peace greatly expanded. The call for help from a distressed world was responded to by every scientist, whose one thought was to discover how he might be of service, and every branch of science took an account of stock to learn what it might offer. In the first years of war the titles of presidential addresses to scientific societies were almost stereotyped; they were all expositions showing how this or that science could be made useful.

Federal science both gained and lost by the tumult of war—gained because its results found a seller's market and finally received recognition; lost because after the war the investigator learned that his services were valued much higher by industry than by the Government. In that brilliant coterie of leaders in thought and action gathered at Washington by the war, the Federal scientist shone, if only by reflected light. If in that, as in all other wars, the volunteer received more glory than the regular, the regular at least gained more than ever before.

It detracts in no way from the splendid war service rendered by every scientific institution in the country to assert that the Federal bureaus were the backbone of war science. They were the vast store-

houses of scientific facts that could at once be drawn upon, and the energies of their great corps of investigators were quickly turned toward the problems of war. As hardly a field of science was not utilized, so hardly one was unrepresented at Washington among its thousand investigators. At the outbreak of the war this great army was fully mobilized, and its staffs were organized. Though not so well disciplined as some wished, it was necessarily better prepared to go over the top at the zero hour than the new recruits, seasoned veterans though many of them were.

At no other time in our history were there gathered together so large a number of leaders of business affairs, and many of these were for the first time awakened to the high commercial value of science. With the signing of the armistice the dollar-a-year man returned to his more lucrative occupation, while the Federal scientist was left to divide his attention between high scientific ideals and high cost of living. The dollar-a-year man lost no time in garnering into his affairs some of the Federal scientists whom he had learned to value during the war. He went further than that, for he robbed the universities of some of their most earnest advocates of pure science.

It seems remarkable that the end of a period when devotion to public duty was the very keynote of the Nation should be marked by a widespread desertion of the Federal service. Men who had long sacrificed their own and their families' comfort found the task no longer to their liking. Veteran Government scientists who had for years continued in the service because of devotion to their ideals realized that their war colleagues from private life were willing, the emergency past, to abandon public service for more lucrative employment. Many investigators no doubt held that they too had done their share of public work and were not called upon for further sacrifice. The loss to the Federal service of experienced investigators is well known though this audience will hardly be willing to accept the statement that "all the able scientists have left the Government service." The egress from the service after the war was so large that the crowded condition of the trains leaving Washington must have been due in part to ex-Government scientists who were being transported to more lucrative positions. Quite as alarming as this loss, though less well advertized, is the difficulty of filling vacancies by the best men from the universities, for it has come to pass that the Federal service now often has only second choice. Many of the best-trained men, who formerly chose the career of Government investigator, now pass directly from the university into commercial life.

This turnover of scientific personnel in the Federal service is to be deplored, for the newcomers are at best but ill trained compared with those that have gone, and they are strangers to the traditions of the service. No doubt some of our critics will regard this as a not unmixed evil, because they hold that bureau chiefs exercise the same functions as the beadles of the University of Göttingen, whose principal duty, according to Heine, was to prevent any enterprising Privat-docent from smuggling new ideas into the institution.

The present trend of the best university graduates away from research and toward industry is a most serious threat to the future of science. Its causes are many and include financial and other post-war conditions. May it not, however, also be in part due to a certain lowering of the ideals of the university student? Because of the high cost of living the teaching staffs of universities, like those of other research institution, have been depleted. Strenuous efforts have been made to increase the salary of the professor, but some of the universities have been forced to temporize by allowing him to devote a part of his time to commercial work. In others the professor, though not actually employed in the business world, has been forced to eke out his small income by preparing textbooks instead of by advancing research. Are we then not justified in asking whether a student's ideal to advance knowledge will be greatly developed by a "revered master" whose academic work is frequently interrupted by industrial demands, or whose contributions to science are textbooks, some of them only too evidently prepared with a view to profit?

Another by-product of the war which may do evil to science is the widespread and more or less blind worship of so-called efficiency. The post-war restlessness has developed a popular fervor for everything that is new or different from what has gone before. No one can find fault with the plan of bringing all scientific activities to the highest degree of efficiency, but there are differences of opinion as to how this can best be accomplished. The American people are sometimes carried away by sentiment rather than by cold reasoning, and any new cause, after receiving the proper label, is pressed forward without thoughtful analysis. Sweeping generalizations are made by unthinking men, and if they make a popular appeal they may receive the assent of the majority. The economies forced by the post-war conditions have made efficiency a national fetish. Unfortunately, the word efficiency has to many lost its true meaning, and because of the success of a certain definite system of improved administration

or operation in industrial plants, it is assumed that a like system should be adopted for all other activities. It is therefore quite possible that the methods of efficiency employed in industry may soon be applied to research. Though no one has yet claimed that these methods would improve our output in literature, this use of them would not be very different from their use in scientific investigation.

Another present popular fetish whose worship is closely related to that of efficiency is the fallacy that all advance has been made by the work of the executive. Our rapid material success has been due largely to the executive, yet the most effective worker in advancing civilization has been the thinker. During the war the organizer and leader was the prime necessity, but our success in the war was largely the result of peace-time thinking. War conditions are not favorable to close thought and careful analysis, and though under the stress of national necessity we made many new applications of our knowledge, it may be questioned whether the stress led to any new thought.

The successful administrator has long been our national hero, and the greatest material rewards have come to him; the thinkers and investigators have always taken the second place. This popular worship of the executive has already affected American science, and even the scientist has been drawn into the maelstrom of administrative duties. Good executive heads of scientific institutions are necessary and should by all means come from those who have themselves carried on research. There is now, however, such a furore for organization that many important researches have been interrupted, because the scientist was dragged into all manner of affairs foreign to his training and experience. If this movement continues, a large part of the best investigators will soon be devoting their time to activities of societies, institutions, or committees the avowed purpose of many which is to advance science. It is then a fair question. If most of the energy of American scientists is to be devoted to the advocacy of research, who is to do the actual investigating? We may be coming to a situation in which drastic action must be taken to send the investigator back to his laboratory. Therefore, any plan of advancing pure or applied science, whose execution involves delay in important researches, may better be abandoned.

There is a widespread belief that all faults of the Federal executive departments can be cured by reorganization. Some discordant groupings of Federal bureaus and of their subdivisions, which lead to inefficiency, are evident. These are so conspicuous that they are some-

times taken as proof that the whole plan is faulty. This is not the time nor place to discuss the broad problem of Federal reorganization, but as any basal changes in the scientific service will affect the individual investigator it must be touched upon.

There is now a great hue and cry about duplication of work in the bureaus and departments. Nevertheless, I venture the opinion that there is but little real duplication in the scientific service. There is a twilight zone between all fields of research that may at will be thrown into this or that one, and therefore it has happened that two bureaus approaching a subject from different direction have found themselves in the same field. The old time bitter interbureau controversies over jurisdiction are disappearing, however, as the result of a spirit of cooperation and the application of common sense, rather than by order of higher authority. Though the branches of some scientific bureaus have found among their number certain strange bedfellows, most of these misplacements have been the results of only temporary expedients.

The errors of some plans of reorganization are due to a misunderstanding of the purpose and methods of science and its terminology. Not many years ago a law was proposed providing that all chemical laboratories should be consolidated in a single bureau. The advocates of this measure, having no comprehension of what was included in the science of chemistry, honestly believed that it was a reform which would result in economy and efficiency. As a matter of fact it was as intelligent as if all work requiring the use of the slide rule should be centralized in the Naval Observatory.

It is to be hoped, therefore, that any plan of reorganization will not be based on confusion between the sounds of words and their true meaning. To me it appears that one question to be asked is whether the organization now charged with any given investigation is doing its work well. If the answer is affirmative, it denotes that the organization has an efficient personnel and a strong *esprit de corps*. The integrity of such an organization should not be sacrificed for the sake of a too rigid system of classification.

I venture the opinion that a sound reorganization will provide for a complete divorce between scientific research, on one hand, and the administration of law and the carrying on of miscellaneous Government business, on the other. In the past these latter duties have sometimes come to bureaus established for scientific investigations, and as a result research has suffered. The investigator is by tempera-

ment not fitted for the duty of administering the law or carrying on other business, and those who are qualified for these tasks are usually equally lacking in the ability to direct research. Therefore, the natural division between Federal functions should be recognized by placing the investigator and the administrator in distinct organizations. Where the facts and their interpretation are needed for the proper enforcement of law the investigator should be called upon, but he enters a foreign field when he undertakes to execute laws.

Kipling has said that "There are nine and sixty ways of constructing tribal lays, and every single one of them is right." The intricate dovetailing of scientific research and its manifold applications to industry gives a choice between a large number of perfectly logical classifications. Therefore, reorganization can well seek to maintain the traditions of the scientific service that have been developed during the century of its growth. Mere antiquity cannot, of course be considered an argument in favor of this or that classification; yet in these days of unrest the preservation of an *esprit de corps* that is the outgrowth of long and effective service should not be lightly cast aside, in spite of the fact that it may contravene the principles of the efficiency expert devoted to cultivating mass effort as against individual effort.

In this all too long address I have attempted to set forth the more significant conditions under which Government scientific work goes forward. By way of summary, I may attempt to answer the question, What has a newly appointed scientist to reckon with on entering the Federal service? It would be easiest to follow the example of many others and dwell long on the darker side of the picture, but we must also see the brighter side.

The financial aspect of his situation deserves first attention, for the new-born scientist probably has not yet learned to put behind him all material things. His first important discovery after, say, six years of expensive education will be that his services are valued at less than those of a journeyman plumber with a professional training of six months, during which his earnings have at least covered his keep. If the scientist remains in the service he can look forward with some hope that his income will eventually overtake his expenses, but this only if he lives humbly, as befits one of his lowly station. While dedicating his life to the public weal he may be cheered by the assurance that at the age of seventy, when he will be unfit for private employment except as doorkeeper, he may be retired on an allowance of $60

a month. This and the interest on the debts he has been forced to contract while he has been in the service should suffice to provide the plain living and high thinking to which he has so long been schooled. If he is truly democratic, he will find comfort in the fact that some aged colleague, whose professional duty in the Federal service was to shovel coal, enjoys the same monthly allowance as his own.

The newcomer will find in the Federal service an atmosphere of activity and high pressure that is not always conducive to constructive thought. If he is favored by fortune he may find that his workshop is a modern laboratory, but he is quite as likely to find that the law has relegated him to the dark corner of a crowded room. In such a corner the distraction caused by the inevitable noise and confusion around him may not infrequently prevent the mental concentration essential to good scientific work.

The new assistant will soon discover that his official actions are more or less controlled by very definite regulations, which may prove irksome to one who has recently emerged from the academic freedom of a graduate school. As he gains more experience, however, he will probably come to realize that good administration of a large organization necessitates some rules and restrictions. Or, like some of his colleagues, he may always hold all restrictions imposed by law to be merely symptoms of bureaucracy.

If the young investigator has had a vision of following a path of self-selected research he will meet with bitter disappointment. He must win his spurs before he can ride to combat. He will find his task definitely assigned to him, probably some small, closely supervised investigation. But if he proves his ability, a larger field will surely open out to him. His excellent training will shorten his apprenticeship as compared with that of his predecessor of generations past. This apprenticeship, short though it may be, will form the necessary introduction to independent investigation. In after life he will probably come to see that his best professional training was gained while he was working under the close control of an experienced colleague.

If the scientist has come to Washington with the purpose of dedicating his life to problems that are unsullied by the sordid needs of man, he has committed a blunder. He will soon learn that grants of public funds are seldom made for research that is not directed toward some ultimate goal of material results. To reach the fixed goal, however, investigations in the fundamental principles of science

must be undertaken. The investigator will soon discover that the Federal service is not favorable for him who holds that if he himself is pleasantly occupied, a demand for results is unreasonable. The bureau chief is not sympathetic with the scientist who believes that, if his own life is not long enough to enable him to arrive at a conclusion, posterity can glean sufficient wisdom from his unfinished epoch-making treatise to justify the expenditure of public funds made on his research.

Sooner or later fiscal responsibilities will come to the new scientist, and if he seeks counsel from his older colleagues, some will tell him that the case is hopeless—that the duty of auditors is to interfere with the progress of science by throwing every available obstacle in its path. If, however, he is of an inquiring mind (as even a Federal scientist may be), he may make the startling discovery, new to many of his seniors, that the Federal fiscal system is comparatively simple, so far as it affects the individual investigator; and also that most of its difficulties arise from laws and not from arbitrary regulations. It will, however, be brought home to him that although scientific bureaus may encourage originality, the Treasury officials find no merit in it when it is displayed in expense vouchers.

The young scientist may meet with some surprises at Washington. He may have pictured the Federal scientific service as a close corporation that attempts to impose its conclusions on the scientific world. In fact, however, he will find that members of the service hold the most diverse opinions, that they are themselves the keenest critics of both results and policies, and that by this characteristic the scientist finds himself in an open forum, where new ideas and new interpretations are most heartily welcomed.

He is not unlikely to find his preconception of his bureau chief to be false. Possibly he has pictured him as a cross between a political lobbyist and an advance theatrical agent—one whose decisions are based on expediency rather than on the rights and wrongs of a situation one whose interest in science is prompted solely by the hope of obtaining popular applause. At close range he will probably find his chief a man deeply interested in the progress of science, who, after devoting years of his life to research, has given it up out of a sense of public duty, for the thankless task of administration. Most certainly he will find him a very much overworked man, bearing a heavy responsibility for the expenditure of vast sums of public money and yet constantly harried by just calls for investigations that are far beyond his resources.

It will soon be disclosed to the young scientist that he has joined a corps of well-trained professional men, keenly alive to the scientific and industrial progress of the Nation. Though he will probably never hear the phrases "public duty" and "self-sacrifice," he will find that what these terms mean is earnestly expressed by actions. Nowhere in the world may he find so many scientists, and whatever his specialty he will meet some whose interests are identical with his own—among them probably a recognized international authority in his particular field of inquiry. Again, he will find his own particular field represented in one of the many local societies. Above all, the young scientist will in time come to realize that the mere mass of such an army of investigators, whose scientific ideals are no less because they include the welfare of mankind, gives an inspiration not excelled elsewhere.

SCIENTIFIC NOTES AND NEWS

By a proclamation of President Harding, signed January 24, a 593-acre tract in the Nevada National Forest has been set aside as the Lehman Caves National Monument. The area remains a part of the National Forest, but can be used for no purposes which interfere with its preservation as a national monument. The caves are in a limestone formation at the base of Mt. Wheeler, at an altitude of 7200 feet, and contain a remarkable series of stalactites and stalagmites.

The Pick and Hammer Club met at the Geological Survey on Saturday, February 4. Professor H. A. BROUWER and the members of the Club discussed informally the tectonic theory presented by Dr. BROUWER before the ACADEMY and the Geological Society on February 2.

At the meeting of the Petrologists' Club on January 17, E. T. ALLEN discussed *Chemical sources of volcanic energy*, and L. H. ADAMS, *Physical sources of volcanic energy.* C. S. ROSS presented a brief note on *A peculiar type of igneous rock in Montana.*

At the meeting of the Physics Club of the Bureau of Standards on January 27, Professor LEONARD T. TROLAND, of Harvard University, spoke on *The interrelation of physics and psychology.* This is to be the first of a series of lectures on the borderline between physics, psychology, and physiology.

At the 25th annual meeting of the local Audubon Society on January 25, Dr. A. A. ALLEN, of Cornell University, discussed *Birds and their relation to man.*

Professor H. A. BROUWER, of the Geological Institute, University of Delft, Holland, visited Washington in February. Dr. BROUWER will give a series of lectures at the University of Michigan, in exchange with Professor WILLIAM H. HOBBS, who is now lecturing at Delft.

Mr. EDWIN F. WENDT, formerly a member of the Engineering Board, Department of Valuation, Interstate Commerce Commission, has opened an office in Washington for the general practice of engineering in connection with the valuation and regulation of railroads, telegraphs, and other common carrier properties.

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OCEANOGRAPHY.—*Some problems of the sea.*[1] R. L. FARIS, U. S. Coast and Geodetic Survey.

INTRODUCTION

It has been well said, I think, that "a presidential address, if there is to be any at all, should be elaborately short and elaborately simple. It should deal . . . . . with general principles, such as can be immediately grasped by every member of an audience."[2] This is good advice, and I hope you will find that I have followed it.

Noah was probably the first person of record to study the sea. He had a sea problem of navigation, of ascertaining his whereabouts and that is probably all the attention that he gave to the matter. The first problems of the sea were probably those of navigation or perhaps such as concerned the local food supply which throughout all historic time has been drawn partly from the sea.

The seas which man found here upon his advent on earth he seems, as a matter of course, to have long considered as a part of his natural surroundings, and generally ceased to trouble himself about them—their size, their depths, their contents, or even their effect upon his life. Yet the area of the seas is much larger than that of all land areas of the earth, and their influence upon his daily life, and even upon his very nature, is profound and persistent. The very ratio of sea to land surface is essential to the existence and development of the present humankind.

It is impossible to predict or even definitely to speculate upon the effect on human life that a different distribution or a different ratio of land and water would bring about, for we have no specific knowledge of any other world arrangement with which to make comparison. I think it quite possible that not many of us have taken thought of how really our lives are dependent upon the existence and the pres-

[1] Address of retiring President of the Philosophical Society of Washington, Jan. 14, 1922. Received Jan. 19, 1922.

[2] L. FLETCHER. Brit. Assoc. Report for 1894, p. 631.

ent distribution of the waters of the oceans, and even from a practical standpoint the great majority of mankind has not bothered itself much about the matter. But when we deal thoroughly with the problems of the sea we must touch upon many fundamental branches of science.

The science of the sea concerns with like interest the biologist, the chemist, the meteorologist, the magnetician, the geologist, the physiographer, the volcanologist, and others, with special subdivisions of their lines of investigations. Also the navigator and the civil engineer have their important practical problems dealing with the sea. Many branches of science meet in and upon the sea, and their boundaries merge into each other.

The sea has made for us a clue to much of the past surface history of the world, for in its depths the remains of the past life of the sea have been filed away as in the archives of nature, and the sedimentary rocks which have been formed tell us something of the physical history of the earth.

A study of the life in the sea is no longer one of scientific interest only, but one of pressing economic importance, as an added source of supply of human food for the ever-growing populations of the earth.

From a biological standpoint, are there any deserts in the sea? Is it possible to cultivate the sea as we do the land, or as we do our oyster resources, or our streams and lakes by stocking with fish?

To utilize our land areas economically, topographic, mineral, forest and other special surveys are essential. Just so, it is important to have a scientific survey of our ocean areas to enable us to take stock of its natural resources, and, having this, thereby to be in a position intelligently to develop and to utilize its resources in an economical and efficient manner.

Aside from being the highway of the commerce of the world, do we also need to use the food resources of the sea for the maintenance of the human race? Or, in other words, must we depend upon the sea to provide a portion of the food necessary for the existence of the coming populations? Does the human body now require for its best development any essential elements of food that can be supplied by the sea only?

If these questions are answered in the affirmative, then, among others, the sea food problem requires our most intelligent attention, especially as the people are even now taking thought of their food

supply, which the tillable land areas of the earth are daily growing less and less able to meet, as evidenced by the rising basic costs of food. Sea foods have been looked upon as desirable, but not absolutely essential, parts of human diet. They may soon become necessary to supplement an inadequate food supply from the lands.

It was the belief of Sir John Murray that the sea is capable of a productivity equal to that of the land. It is generally estimated that less than five per cent of man's food now comes from the sea. If so, then the sea has unrealized possibilities of utilization that are vast from the economic standpoint, and a comprehensive study of these possibilities should not be overlooked or neglected, especially by maritime nations.

As the land areas are made subservient to the practical needs of man just so must the sea be made more useful in supplying the needs of the human race, both physical and cultural. But the utilization of the resources of the ocean must and will follow its scientific investigation and study. Let us find out what is in the sea, and then learn how to apply it to our needs.

As our frontiers are pushed farther and farther toward the limits of our country we hear more and more about the conservation of our natural resources, while here on the borders of the continent lie untold resources awaiting our investigation and industrial development. So whatever science can do in its investigation of the sea and all that therein is, cannot fail to have its important interest for us in the practical bearings it must eventually have upon our daily lives.

In the sea, as in no other place, do we observe the tireless energy of the universe depicted at all times. The hydrosphere, like the atmosphere, is never still in all its parts. It epitomizes and visualizes the energies of creation. And the inhabitants of the sea, by long processes of adaptation, are no doubt dependent upon, and aided by, these ceaseless motions which assist their distribution and prevent overcrowding, and aid in the provision of food which is a necessary condition of their life. The circulation of the waters of the sea is a vital benefit to the life of the ocean creatures, just as air circulation is vital to the living organisms of the land. The circulation of the waters in the great ocean streams has also a climatic influence upon the life on the land areas of the world as well as upon the life in the sea. It is the climatic balance wheel for many regions, ever striving toward an equilibrium which fortunately is never quite attained. The sea has its seasons no less than the land.

In fact, as we learn more and more of the physical facts of the sea, we also learn of their important influence upon our lives.

I suppose that nearly all the problems of the sea that are really worth while have already been suggested and more or less studied by some one, and many of them are at least partly solved, but my wish is to emphasize strongly the necessity for an intensive pursuit of those that have scientific or economic value, and for concerted effort and standardized action, that an awakened and sustained interest may be had in those problems, especially by all those nations whose borders touch the oceans and who thereby must the more readily realize the importance of, and be much interested in, such matters.

Much more of actual observations at sea and in the sea is needed to verify existing theories or to modify them to conform to the further facts of observation.

The mechanical problems of the sea are more nearly solved than its physical ones. The helps to the navigator are far advanced, and the life-saving and property-saving appliances are well up to date, so that the mariner sails on a more familiar sea than the oceanographer or the geophysicist. But this is only because his problems were the more immediate, and the aid of the scientific method and of science was first applied in his direction for very obvious reasons; he has been here with his practical problems since the birth of modern science and has stood ready to apply its findings to the betterment of his art. The applications of radio communication have become the genius of ocean navigation, and of longer distance weather predictions.

Yet it is not possible clearly to separate the pure science from applied science in oceanography, as the needs of the one stimulate the other, and the discoveries of science soon become the necessities of the practical navigation and other economic uses of the sea.

OCEANOGRAPHY

Oceanography, the general term by which the science of the sea is now come to be designated, is a comprehensive term which embraces a number of rather distinct branches of investigation and study, but many of which, owing to the nature of the problems, are generally carried on simultaneously. It certainly would be most economical and efficient that as many as possible of the physical investigations of the sea be carried on simultaneously by the same exploring expedition. The equipment for sea exploration is expensive at best, so that the

more comprehensive the investigations can be made, the more economically will the results be obtained.

Oceanography as this term is now applied is not an old science. Some twenty years ago Sir John Murray[3] said of it:

The recognition of oceanography as a distinct branch of science may be said to date from the commencement of the Challenger investigations. The fuller knowledge we now possess about all oceanic phenomena has had a great modifying influence on many general conceptions as to the nature and extent of those changes which the crust of the earth is now undergoing and has undergone in past geologic times. Our knowledge of the ocean is still very incomplete. So much has, however, been acquired already, that the historian will, in all probability, point to the oceanographical discoveries during the past forty years as the most important addition to the knowledge of our planet since the great geographical voyages associated with the names of Columbus, DaGama, and Magellan at the end of the fifteenth and the beginning of the sixteenth centuries.

There are probably no longer any frontiers on land or sea to explore, except perhaps some parts of the polar areas, yet upon the sea there is one region of two million square miles that has never felt a cast of the sounding line, nor much of other investigation.

The extreme depth of the ocean has probably been approximately approached, and now turns out to be somewhat in excess of 5300 fathoms (31,800 feet), somewhat more below sea level than the highest elevation of the land above the sea; thus making the summit of the highest mountain about ten geographic miles above the deepest known "deep" of the ocean.

While we now have much information about the physical geography of the oceans and detailed surveys have been made of their borders in the more advanced countries of the world, there yet remains the larger part of the sea coasts to be surveyed and mapped by such modern methods and equipment as will meet present and future requirements of science, engineering, and commerce; especially is this true of the coasts of the Pacific Ocean, and of the polar regions.

A knowledge of the physical form of the ocean basins is fundamental to almost all of the branches that go to make up the whole science of the sea, and, together with other physical facts, is a guide to many industrial possibilities existing therein.

I think that there can be no doubt that the lack of accurate knowledge of the form of the ocean basins has already retarded industrial progress, commercial development, and scientific and cultural advancement of the world.

[3] President's address, Section E (Geography), Brit. Assoc. Report for 1899.

In the Atlantic Ocean, beyond the 1000-fathom depth, there is now one sounding for about each 12,000 square miles; in the Pacific, one sounding for each 25,000 square miles; and in the Indian Ocean one sounding for each 26,000 square miles. The depths of the polar seas have been explored only to a most limited extent or virtually not at all. Owing to the methods of navigation and of deep sea sounding, when the earlier of these soundings were recorded, it is quite possible that their positions and depths now ought to be verified by modern methods.

The major part of the sea coasts of the world is not yet surveyed and charted with the accuracy now needed, and many thousands of miles of the coast lines are not surveyed at all, and still other parts not even approximately sketched.

In our own country nine-tenths of the coast of Alaska is not yet surveyed, and the Pacific Coast of Continental United States is for the large part yet undone, while the need for surveys is urgent and commercial development is retarded and delayed.

Only about one-seventh of the land area of the world is in any wise adequately mapped, and the form of the sea bottom is proportionately not so well known as the topography of the land. The surface of the sea holds less of interest to mankind than the surface of the land; however, to the man of science, the bottom of the oceans, if it could be exposed to view, would no doubt reveal equally as much of scientific and popular interest as the land surfaces.

We have been mapping the land by various means and methods for many centuries, while the mapping of the coasts and ocean basins has been undertaken seriously for a bare century and a third, and with only a comparatively small number of vessels and by only a few nations. So it is readily understood why the undersea form of the earth is not yet known to any very conclusive extent. In the matter of charting the sea coasts and depths of the oceans, it is well known that all nations are lagging far behind the practical needs of ocean commerce.

At the time of Columbus' voyage of discovery to the new world there were no charts showing the depths of the sea, nor the exact boundaries of any ocean. In the year 1504 Juan de la Cosa made a map showing soundings in shallow waters. Magellan, in the year 1521, was probably the first to attempt to sound the ocean depths.

Up to the present time the total number of soundings that have been charted in the three larger oceans beyond the 1000-fathom

depth probably does not much exceed seven thousand,[4] including many of the earlier ones that ought now to be verified, both as to position and depth of water; or an average of one sounding for each 17,000 square miles. To compare this with what ought to be done in order to have a complete general deep sea survey it should be stated that at least one hundred and fifty thousand soundings are needed, spaced at intervals of about thirty miles, with necessary local development. This would require ten ocean-going ships in continuous service for ten years. And this means that each vessel must take four or five deep sea soundings every day of the year throughout these ten years. If, however, these vessels should carry on other oceanographical investigations, as they most certainly should not fail to do, the time would be much longer.

From physiographic and biologic standpoints the borderland of sea and shore, the so-called continental shelf, holds a closer claim upon our attention than any other part of the sea. This is the most populous part of the ocean as regards the different forms of sea life; and here also the physical forces of the sea are most manifest and effective in producing the physiographic transformation that the face of the earth is experiencing without cessation.

The force of the ocean waves is spent upon the sea shores in an endless and tireless evolution. The study of the processes of erosion and accretion of sea shores is one of importance to the scientist and the engineer alike. A study of these involves a knowledge of tides, currents, and wind-produced ocean waves. The causes must be studied and the effects observed from time to time.

The larger part of the coast lines of the oceans, like the interior of the continents, yet remains to be charted in accordance with the present-day requirements. The sea bottom from the shores to the edge of the continental shelf should be surveyed and mapped to meet the needs of commerce, industry and science, all of these being vitally concerned in the undersea physiography of this transition belt between the land areas and the deep sea.

A survey and study of the ocean depths surrounding the islands of the seas will doubtless do much towards giving us a clearer conception of coral formation and growth, and add to our knowledge of subsidence or emergence of land areas.

The charting of the ocean basins from their shores to their profoundest depths is one of the outstanding problems of the sea. The

[4] MURRAY and HJORT. *Depths of the Ocean*, p. 131.

importance of it is especially known to all who have anything to do with oceanography. The problem is also so large that nations are thinking more seriously than ever before of how its solution can be expedited by cooperative means. It is now fully realized that it is a problem for all nations; it is no longer considered national but is admittedly international.

The most recent evidence of the crystallization of authoritative opinion concerning the international character of the hydrographic survey of the oceans, is the formation during the past year of the International Hydrographic Bureau, which has in its membership representatives of most of the maritime countries of the world. The object and powers of this Bureau are stated essentially to be:

> The establishment of a close and permanent association between the Hydrographic Services of the Associated States, to coordinate their efforts with a view to rendering navigation easier and safer in all of the seas of the world, to cause the national officers to adopt the Resolutions taken by the various International Hydrographic Conferences, to try to obtain uniformity as far as is possible in hydrographic documents, and finally, to advance the theory and practice of the science of hydrography.

Among the subjects which the Bureau suggests for study is "Researches on the subject of the constitution of the earth, in so far as it affects hydrography."

In reference to many other subjects that make up the science of the sea, the present-day attitude of men of science in regard both to the magnitude of the problems confronting them and to the essential need for unified action of all nations in attacking the problems now pressing for solution, is well reflected in the meeting of the First Pan-Pacific Scientific Conference fittingly held in Honolulu in August, 1920.

The papers presented and the subjects discussed at those meetings are quite sufficient to convince us that much the greater part of oceanographic work lies ahead of us, and that adequate progress requires the efforts of all nations, and also that the work of the surveys and investigations should be henceforth speeded up materially.

Oceanic circulation.—Now briefly to touch upon some other of the larger problems of the sea; the courses of the currents that make up the system of oceanic circulation have been mapped in a general way but our knowledge of these streams is far from satisfactory. Our information concerning the strength and direction of ocean currents is largely dependent upon the set experienced by vessels traversing the oceans. And this is based on the difference between the true and the dead-reckoning positions, which does not permit of great accuracy

in determination. Supplementing the information from this source there are a large number of records of drift bottles, wrecks and other floating objects. But at best these permit conclusions of a qualitative nature, *only*. We still lack observations that will permit of quantitative conclusions, and these can come only as the result of systematic observations.

Results of a divergent character are found in the records of drifting objects. It is only by the use of great numbers of records of this character, that conclusions, even approximately correct, may be reached. Thus the whole subject of oceanic circulation is still relatively a virgin field. For each of the currents investigations are needed to determine its extent, its width, vertical and horizontal velocity distribution, and its wind and seasonal variations.

Even in the case of the Gulf Stream, upon which considerable good work has been done, there is still needed much work of a quantitative kind. For instance, it is known that the position of the velocity and temperature axes of the stream are not necessarily coincident. But the exact relation between the two yet remains to be discovered. Likewise the seasonal changes in the positions of these two axes, and the variations in velocity and temperature due to changes in the velocity and direction of the winds, yet remain to be investigated. Considerable additions to our knowledge of the Gulf Stream can yet be made regarding the horizontal and vertical distributions of velocity of currents, temperature, density, salinity, and their variations with the winds and seasons. This involves, also, elaborate tidal and current observations in the Caribbean Sea, the Gulf of Mexico and the adjacent waters of the Atlantic Coast, and possibly across to the European Coast.

Tidal currents.—Intimately connected with the tides and forming a part of the same phenomenon are the tidal currents. Out of sight of land, tidal currents are generally very weak. But there they offer an interesting field for study, since off-shore they are most frequently of the rotary type. Close inshore considerable work remains yet to be done to bring out the characteristics of local currents, especially in the less frequented places of the world. There is also need for investigations of a local character to determine the changes in the current velocities due to winds and changes in atmospheric pressure.

Such investigations are of the greatest importance, aside from their scientific value, in safeguarding navigation, in harbor works, and in coast protection.

Tides.—Of all the phenomena of the sea, the tides seem to have been among the first to attract man's attention, although there is an interval of at least two thousand years between the earliest mention of the tides that has come down to us, and the time when Jeremiah Harrox first undertook a series of three months' continuous tidal observations in the year 1640.

Our knowledge of the tides is based almost entirely on observations confined to the immediate vicinity of the coast. Observations have not yet been made in the wide stretches of the open ocean; and even close inshore where the difficulties of measuring the rise and fall of the tide are much less, little has been done, and there are numerous localities along the coasts where accurate information is still wanting. There is need of investigations to determine for each locality the changes from the normal heights of the tide, due to wind and changes in atmospheric pressure.

The tide-producing forces are definitely known, but the problem of correlating these forces with the time and height of the tide at all places on the earth by means of a general formula is yet to be solved and much more of observation is needed where none as yet exists, especially in the open sea, for the settlement of the question of the general tidal theory.

Mean sea level.—Closely related to the subject of tides is the question of mean sea level and its relation to elevation of the land of the sea coasts. By mean sea level, I mean that resulting from continuous tidal observations over a period of at least one complete lunar cycle of approximately nineteen years' duration.

I do not see just how we can know anything definite about the variations of mean sea level. The sea areas are so much greater than the land areas of the globe that I think we must assume for all practical purposes that mean sea level remains practically constant and that any changes in vertical distance between reference points on the sea coast and the mean ocean surface are due to the movements of the land, and not to variations of mean sea level. The problem therefore becomes one of determining the elevations of the coasts with reference to the mean level of the sea. This problem is of much importance to the engineer and the scientist, especially the geologist and geophysicist. Measurements on land and sea are all referred to sea level wherever a vertical reference point is required. Many of our industrial works are based on this reference plane, and on account of its invariability and readiness of reproduction, it is a natural standard.

It is therefore important that the relation of the land elevations to sea level be studied and accurately known. A knowledge of this relation is vital to the study of the subsidence or emergence of land areas.

That there have been great uplifts and subsidences in the surface materials of the earth in past ages is well known. How long these were in being accomplished, especially the uplifts, is not so well known. Adjustments of the material of the lithosphere have not ceased, and these adjustments generally result in some changes in reference to sea level.

Of course the duration of one generation is a short time in which to study by physical observations any facts of subsidence now in operation, but the observations should be arranged by this generation and carried out systematically and handed on to the next, so that cumulative evidence may later establish what the facts are relative to changes in land elevations.

These observed facts must be closely related to tidal observations of one or two years' duration all along the coasts, connected by lines of precise levels. These tidal observations must be simultaneous with tidal observations at standard base tidal stations where a long series of observations have already been or are being secured.

No systematic work for accurate subsidence determinations has been carried out anywhere, as far as I know, though there are a few cases where precise levels were run between bench marks after intervals of from 25 to 78 years.[5] Our present knowledge of the changes in the relation of sea and land elevations (except those due to sudden changes) depends almost entirely upon deductions from geologic evidence found in the fossil remains of sedimentary rocks, studies of coastal erosion, and perhaps in the study of coral reef formation about the coasts and around the islands of tropical seas.

In this connection it seems proper to emphasize the importance of having hydrographic surveys about the islands of the tropical seas especially, not only for geographical reasons and for purposes of safer navigation but also for the use in the study of coral formation and also to afford us information of shore line changes effected through subsidence, uplift, and erosion.

Terrestrial magnetism.—The problem of the earth's magnetism is about the most difficult of all the unsolved problems of geophysics. The data requisite for the study of this problem include magnetic observations over the ocean areas, not only to measure the magnetic

[5] Geograph. Rev. 3: 136–137. 1917.

elements but to ascertain the secular change of these elements, to outline the disturbed areas, and to discover the effect of ocean depths.

As far as I am aware only two specifically organized magnetic surveys of the oceans have ever been established, that of Edmund Halley in 1698, and that at the present time of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington; the latter being by far the most comprehensive and extensive, covering the seas from latitude 60° south to 60° north, this sea work being supplemented by many hundreds of stations on land in countries where such work is not being actively carried out by the nations themselves.

Most excellent work is being done, and the first magnetic survey of the oceans may be said now to be nearing completion, but observations for the secular change data must be kept up. To keep the secular change data up to date, and to fill in as yet unsurveyed areas, will probably require the time of one expedition continuously.

Additional magnetic stations are especially needed in the polar regions, especially in the north polar area. No opportunity should be neglected by any surveying or exploring expedition to obtain magnetic and allied observations wherever needed. Such electrical observations as may be found necessary and practicable should also be carried out in connection with the magnetic observations at sea.

Gravity observations.—A problem of much importance in the study of the physics of the earth is the determination of the intensity of gravity at sea first, to furnish further information that will enable us to ascertain more accurately the shape of the earth, and second, to determine the distribution of the densities in the so-called "isostatic shell" of the lithosphere.

Researches in this and other countries have made it certain that the outer seventy miles of the earth's material is in a state of approximate isostatic equilibrium. If we assume a surface seventy miles below sea level under the continent and on this surface lay out squares approximately one hundred miles on a side and extend vertical planes from these sides to the surface of the earth, we should have the same mass in each of the columns, though some of the columns would be a mile or more longer than others. In other words, each column of equal cross section is found to have about the same pressure on the nucleus at a depth of seventy miles below sea level as any other column.

Do these conditions exist under the ocean? The answer to this question requires the obtaining of observations for the intensity of gravity over ocean areas.

Observations for the determination of intensity of gravity have been made at sea by several types of apparatus, but the accuracy of these observations has only been sufficient to show that the intensity of gravity under ocean areas followed closely the laws of change of gravity with latitudes that are found to obtain over land areas, but the observations are not accurate enough to test the isostatic condition of the ocean basins.

Some modification of the present instruments and corresponding change of method of observation are needed, or possibly some instrument devised along entirely new lines from those heretofore employed finally may be found necessary to get the accuracy required.

The solution of this problem is a matter of prime importance to geologists and geophysicists in many of their studies.

Meteorological observations.—To know the state of the weather in advance of its occurrence is an important matter to us whether we be on land or sea, and the economic value of such information is well known. In fact a foreknowledge of the weather has had such an immediate economic value that the practical side of meteorology has developed to a greater degree than the theoretical side of the problem.[6]

We have much less meteorological observational data over ocean areas than for the land areas, though the ocean areas are of much greater extent. The gathering of meteorological data more completely over the regions of the oceans is an important problem of the sea, and for us especially in the Pacific Ocean and Bering Sea. In this all ships that traverse the oceans can also continue to render valuable service, by making meteorological observations, reporting them by radio, and following with full reports by mail.

The need for much more ocean meteorological data is plain, and their scientific and practical value so evident that no opportunity for obtaining them should be disregarded.

Another problem said to be of promising importance is the observation of the tides and their correlation with the paths of approaching hurricanes.[7]

Ocean temperatures.—One of the most striking deficiencies in our knowledge of the physical facts of the sea is that of ocean temperatures. In the whole of the vast Pacific Ocean, for example, there are only something like seven hundred lines of temperature observations,[8] by

[6] Proc. Nat. Acad. Sci. **6:** 561.

[7] Science **52:** 638–639. Dec. 31, 1920.

[8] Annalen der Hydrographie, **38:** 5. 1910.

far too meager a number with which to delineate an isothermal chart of such an ocean. Lines of temperature observations are much too few in all of the oceans, to say nothing of temperature data sufficient for ascertaining the facts of variations of temperature, seasonal or other at any place, except in the regions about the North Sea, the Baltic and in the Mediterranean.

A knowledge of ocean temperatures at all depths, and for different seasons of the year, is one of great significance to the science of physical oceanography, and is one of its outstanding needs at this time. It is fundamental to the study of ocean circulation and to the problems of the marine biologist, and is believed to be a fair index, as well, to certain configurations of the sea bottom.

Closely related to the problem of ocean circulation and to some of the problems of marine biology is the salinity of the ocean waters. The salinity varies throughout all of the waters of the sea, and a better knowledge of its variations, especially the vertical distribution, is most important, and is as yet not even so well known as the vertical distribution of temperature.[9]

Sedimentation.—In oceanographic surveys bottom specimens should be secured when sounding the depths of the sea, in order to secure samples of the materials of the ocean floor for the study, among other purposes, of sedimentation, which is fundamental to the geologist in considering sedimentary rocks. The character and chemical constitution of the deposits on the ocean floor is of prime importance to the marine biologist and the volcanologist. The bottom specimens should be secured in such a way that it can be ascertained how the deposits are serially laid down, and this requires as deep a penetration as possible for the specimen-gathering device.

In contemplating the many problems connected with a study of the sea it is at once realized that it is not possible even to mention many of them within the time at my disposal and one at once comes to the thought how great is the task of finding out what is in the sea, and it is the magnitude of this task that should urge the maritime nations of the world to a more serious and active consideration of those problems as to how they may be more expeditiously carried out. To this end international cöoperation is essential, for it is a world problem, and of equal importance to all.

The units for the oceanographical investigations should be as comprehensive as can efficiently work together. For the most effi-

[9] Ency. Brit. ed. 11. p. 983.

cient service the vessels employed on oceanographic work should be designed and constructed for that specific purpose; the design to be based on a careful consideration and study of the purpose and requirements involved in the investigations that are to be carried out. A laboratory should be provided on board the vessel so that chemical, physical and biological investigations can to some extent be carried on while the vessel is on the working grounds. The instruments and equipment, and the methods of their use, should be standardized and up-to-date. And in order to secure standard instruments and methods these matters should be considered and passed upon by a body composed of competent representatives of all cooperating nations. This body should also draw up a manual of instructions for the oceanographic work. Then all investigations carried out at sea by the different expeditions would be of a readily comparable character.

After the sea investigations have been made the most important thing is the earliest possible publication of the results in such form, at least, as will make them accessible to all students of the subjects concerned. There are a number of institutions already in existence, and others could be established if necessary, where this could be done. In other words, these institutions would be the clearing houses where the results of the oceanographic investigations would be studied, correlated, and published.

CONCLUSION

My thought and purpose throughout this paper has been to put before you in a most general way, the fact that although much has been done in the investigation and study of the sea, and that also there may be but few, if any, new regions to explore or new problems arising, yet as regards the details of existing problems yet to be searched out and correlated, a good beginning only has been made, and that the work yet needed to be done is so large as to require the combined effort of all maritime nations, also that the need for the work is really more pressing than its present rate of accomplishment indicates.

Let us do what we can to popularize this subject; to show its scientific and cultural as well as its economic aspects. Let us interest the public in the value of knowing and cultivating these great ocean fields, to learn more of Nature, as well as to make the lives of coming generations more certain and secure.

Science applied to our national resources, has made the great industrial development of America, but with this development the needs of the rapidly growing nation have correspondingly increased, so that today we are forced to take thought of the remaining natural resources of the land. A study of the sea will widen the field of our natural resources as well as extend the limits of human knowledge and culture.

ENTOMOLOGY.—*New species of the coleopterous genus* Trox. H. F. LOOMIS, Bureau of Plant Industry. (Communicated by O. F. Cook.)

Preparatory to describing a very extraordinary species of *Trox* recently collected in Arizona, an examination of the closely related forms was made which led to interesting findings regarding the classification of these species. The identification, on external characters, of the species of this genus has been considered an easy matter and the genus has received little attention from systematists for many years. As in many other insects, very reliable specific differences are exhibited by the male genitalia in this genus. This structure shows that in the material hitherto identified as *scutellaris* Say, in the National Museum, three very distinct species of great superficial resemblance are included. That this resemblance has caused these species to be confused in most collections is probable and other cases of a like nature may occur, an examination of the male copulatory organs being necessary to separate the species

In the specimens of *platycyphus* and *scutellaris* the wings were found to be greatly atrophied and represented by only a short and very narrow vestige while in *oligonus* they show much better development and bear far more resemblance to normal wings.

Only the larger species, those having the thorax strongly constricted behind, are dealt with in this paper. The male genital organs of all the species belonging to this group in the United States have been figured to facilitate recognition of the species. The figures were made with the aid of a camera lucida and all are drawn to the same scale. The copulatory organs of the female probably will also exhibit good specific characters but they are not considered here.

Six species described by LeConte in 1854 have been reduced to varietal rank under *scutellaris* and *punctatus* but the writer has been unable to identify any of these from the external characters mentioned in the original descriptions. Their validity can be decided only after study of the genitalia of the LeConte types. In this paper specimens collected at Pueblo, Colorado are assumed to be *scu-*

tellaris Say (type locality, "Upper Platte"), and a specimen of this typical form is before the writer from southwestern Texas (between Pecos River and the Guadeloupe Mountains).

Trox platycyphus Loomis, sp. nov. Shape oblong-oval, the color black and shining when clean. Length 14 to 19 mm. Habitat, southern Texas.

Thorax strongly constricted at basal third; posterior angles obtusely rounded, a slight emargination immediately in front of them; tubercles strongly shining, much more sparsely and coarsely punctured than the rest of the surface; tubercles of the posterior series oval, the median pair larger; in front of each outer one and belonging to the anterior series is a smaller tubercle; the usual ridges of the median pair of tubercles of the anterior series coalesce causing the tubercles to appear broad and flat; from each of these, on the inner side, a narrow, usually unpolished ridge extends backward between and nearly opposite the middle of the inner pair of tubercles of the posterior series. Elytra with the tubercles transversely confluent, much flattened, smooth and shining; rows of large and small tubercles alternating, four rows of the large, six of the smaller, two of these smaller rows between the suture and the first large row; series of punctures much confused by transverse coalescence of tubercles; entire surface of the elytra glabrous.

The male genitalia large and with very pronounced constriction near the apical third; median lobe not attaining apex of the lateral lobes; outer sides of lateral lobes almost parallel with a very abrupt constriction on the apical third which reduces the width of the lobe nearly one half, the lobe then continuing to a rather broadly rounded extremity; dorsal surface of lateral lobes at the constriction abruptly declining giving the narrowed apex a lower level; basal pieces long and rather broad. FIG. 1, A.

Type and paratypes No. 25198, U. S. National Museum.

Described from nineteen specimens from Cotulla, Texas, collected April 17, 1906, by F. C. Pratt. Other paratype localities in Texas are Knippa and Sabinal, one specimen from each (*F. C. Pratt*), and San Diego, two specimens (*E. A. Schwarz*).

The pair of complanate median tubercles of the thorax, the confluent elytral elevations and the form of the genitalia are the salient features of this species and separate it from *scutellaris* and the species which follow it.

Trox oligonus Loomis, sp. nov. Large and broadly oval, robust species; shining black when clean. Length 16 to 18 mm. Habitat, Texas.

Constriction of thorax moderate and resembling *scutellaris* although not as long; margin in front of hind angles faintly emarginate; tuberculation as in *scutellaris*. Elytra with rounded and moderately distinct tubercles in ten rows, none of which predominates; usually a few spicules in a small patch behind each tubercle; intervals between the rows of tubercles with a series of punctures which are finer than in *scutellaris*. Vestigial wings short, rather broad.

Male genitalia comparatively small; sides of lateral lobes not constricted at apical third as in *scutellaris* and the preceding species; tip of median lobe more acute, reaching nearly to tips of the lateral lobes; basal pieces broad and long. FIG. 1, C.

Type and paratypes No. 25199, U. S. National Museum.

Described from a series of nine specimens from Texas; five from the type locality, San Diego, collected by E. A. Schwarz, April 30 to June 12, 1895, and

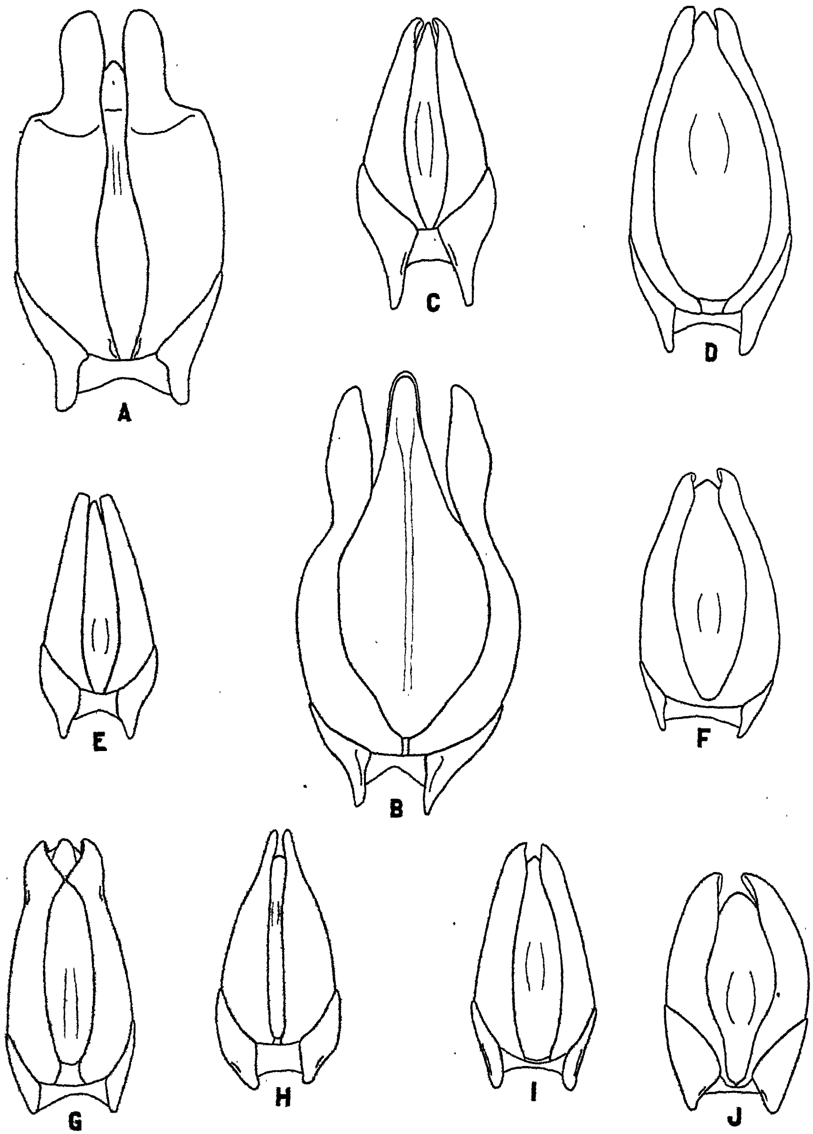

Fig. 1. Male genitalia of *TROX*.—A, *T. platycyphus*, n. sp; B, *T. scutellaris* Say; C, *T. oligonus*, n. sp.; D, *T. inflatus*, n. sp.; E, *T. scabrosus* Beauv.; F, *T. monachus* Hbst.; G. *T. asper* Lec.; H, *T. suberosus* Fab.; I, *T. punctatus* Germ.; J, *T. carinatus*, n. sp.

one specimen from each of the following localities,—Encinal (*J. D. Mitchell*), Santa Rosa (*H. S. Barber*), El Paso (*F. C. Pratt*), and Lamesa (*E. G. Holt*).

Distinguished by the rounded tubercles of the elytra which are seldom confluent and in rows of equal size, and also by the size and shape of the male genitalia.

Trox inflatus Loomis, sp. nov. Body smaller and more slender than *scutellaris*, elongate-oval; color black and shining when clean. Length 14 to 15 mm. Habitat, Arizona.

Thorax strongly constricted, in this respect resembling *suberosus;* hind angles broadly rounded and with only a slight emargination of the margin in front of them; disc moderately elevated, tubercles distinct, the outer ones of the basal series the larger; in front of each are two smaller ones belonging to the anterior series which, with the large median pair, is composed of six tubercles. The four rows of elongate and flattened tubercles of the elytra hardly to be distinguished from the intervals between them; these intervals are raised at short distances into slightly less distinct elevations which lack the small tomentose areas following the tubercles of the major series; usually a few small spicules in the depressions of the intervals, a single spicule located above each of the deep punctures on either side of the intervals; elevations of the intervals often confluent with the tubercles of the adjacent rows; second series of tubercles ending on apical fourth in a faint umbone. FIG. 1, D.

Type and allotype No. 25200, U. S. National Museum.

Described from two specimens; a male collected in a moist recess among rocks on the top of a desert peak near Sacaton, Arizona, November 23, 1921, by H. F. Loomis, and a female collected on Ash Creek in the Graham Mountains of Arizona, July 2, 1914, by E. G. Holt.

From the size and general shape of the copulatory organs of the male this species is related to *scutellaris*, but it differs in having the median lobe greatly inflated and visible above the lateral lobes when viewed from the side; the tip of the median lobe is less slender and the lateral lobes are not abruptly constricted on the outer side near the apical third above which the lobes are not as greatly expanded.

Trox carinatus Loomis, sp. nov. Form oboval, less compact; color black, surface feebly shining when clean. Length 12 to 13 mm. Habitat, south central Arizona.

Constriction of thorax longer than in any other species dealt with, emarginate throughout its length; margin sharply incised in front of hind angles which are acute and remote from the humeri; disc strongly elevated; tuberculation resembling that of *asper* though hardly as coarse. Elytra each with four prominent carinae replacing the rows of large tubercles, the two inner carinae more pronounced; second carina ending on the apical fourth in a tomentose and dentiform umbone; all carinae with small tomentose patches on the outer side; intervals between the suture and the first carina, between the carinae themselves and between the last carina and the elytral margin each with two rather widely separated rows of large and deep punctures; surface between the rows and between the punctures in the rows smooth and evenly rounded. Front tibia with a well developed tooth at apical third; upper face with two rows of rather large punctures.

Copulatory organs of the male relatively short and broad; median lobe

stout, not attaining tips of the lateral lobes; inner margin of lateral lobes strongly arcuate; basal pieces broad and enfolding much of the lateral lobes. Fig. 1, J.

Type and allotype No. 25201, U. S. National Museum.

Described from two specimens; a male collected with the male specimen of *inflatus* near Sacaton, Arizona, November 23, 1921, by H. F. Loomis, and a female collected in the "nest of a rat among rocks" (probably *Neotoma*) near Tucson, Arizona, January 2, 1897, by H. G. Hubbard.

This species should probably be placed after *punctatus;* the carinate elytra, the form of the thorax and the genitalia distinguishing it from that species and all others. Tibial punctures are found in most of the species of *Trox,* but their size and disposition have some specific importance. In *scabrosus, monachus* and *asper* these punctures are small or entirely lacking, in the other species here treated the rows are much more irregular than in *carinatus.*

ABSTRACTS

At a meeting of the Council of the Washington Academy of Sciences on January 16, 1922, it was decided to discontinue the section of formal abstracts in the Journal. It will be replaced by a section devoted to brief notes of recent publications.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

A special meeting of the Botanical Society of Washington was held at the Cosmos Club on Monday, June 26, 1921, to hear Prof. J. F. Rock of the Office of Foreign Seed and Plant Introduction, who had just returned from an extended trip in the Orient, where he traveled up the rivers of Siam and Burma and through the forests to find the chaulmoogra oil trees. This oil has lately been used in Hawaii for the treatment of leprosy with such success that already two hundred patients have been declared free from all sumptoms of the disease. According to Hindoo legend and literature, moreover, this oil has been used for a thousand years by the natives of the Far East.

The trip was made by Prof. Rock for the purpose of investigating the various species of *Taraktogenos* and *Hydnocarpus* and to collect viable seeds for germination purposes, especially those of *Taraktogenos kurzii* which seeds are known to produce the true chaulmoogra oil.

Hydnocarpus anthelmintica was obtained by Prof. Rock in Bangkok and Eastern Siam. Camp was established in the northern Lao States on Mt. Dai Chom Cheng and this mountain was explored for economic plants, among which species of *Castanea* or chestnuts, and a number of *Quercus* or oaks were secured. He followed the Meh Ping River by Lao houseboat to Rahong, a journey of ten days, making collections on the way. From Raheng he crossed overland with coolies to Moulmein, Burma, thence to Martaban, where *Hydnocarpus castanea* was obtained. The first specimen of *Taraktogenos*

kurzii encountered was at Thynganyinon, one day's journey from the Siamese Boundary in Burma. From Martaban he proceeded to Rangoon, thence to Monywa on the Upper Chindurin. From there he went by boat (stern-wheeler) to Mawlaik in northwestern Burma. At Mawlaik he was informed that *Taraktagenos kurzii* could be obtained near some jungle villages on the Khodaun stream. The best locality and where he found pure stands of *Taraktogenos kurzii* was near Kyokta, a small village of about thirty houses. Seeds were collected in large quantities and forwarded directly to Hawaii and Washington after the party again reached civilization. In northeastern Assam,. in India proper, seed was secured of *Gynocardia odorata*, and of *Taraktogenos kurzii*, which is also found there.

Besides finding *Taraktogenos kurzii* and photographing it for the first time, Prof. Rock found a number of hitherto unknown species belonging either to *Taraktogenos* or *Hydnocarpus*.

Gathering of the seeds of the chaulmoogra oil tree has been a regular occupation of the natives for generations. This seed collecting, however, has been carried on very uneconomically because of the fact that the animals of the forest feed upon the fruit, and destroy a high percentage of seed, the natives getting only what the animals leave. The supply of seeds in the world's market is therefore very inadequate. Prof. Rock's work, therefore, was to find the trees that produced the seed and make collections of seed of *Taraktogenos kurzii* and other chaulmoogra oil-producing species so that the trees could be introduced in cultivation. This he succeeded in doing, traversing the forests of Siam and Burma where few white men had ever gone.

The Government of Hawaii has set aside one hundred acres of suitable mountain slopes for the planting of these species. The seeds brought back have all germinated and are growing well both in Hawaii and in this country.

Following Prof. Rock's address Dr. F. B. POWER, authority on the chemistry of the chaulmoogra oil, was called upon for remarks.

After expressing his appreciation of the interesting and instructive discourse by Professor Rock, Dr. Power spoke as follows:

"My attention was first particularly drawn to the subject of chaulmoogra oil while in London by an inquiry from the Leper Hospital at Robben Island, South Africa, respecting its active constituents. At about the same time it was recorded by Mr. E. M. Holmes (*Pharm. J.* 1900, **64**, 522; 1901, **66**, 596) on the authority of Sir David Prain, then Director of the Botanic Survey of India and now Director of the Royal Botanic Gardens, Kew, that chaulmoogra oil is not obtained from the seeds of *Gynocardia odorata* R. Br., as had previously been assumed, but from the seeds of *Taraktogenos kurzii* King. Shortly after these observations a large quantity of true chaulmoogra seeds was brought into the London market, and this afforded an opportunity for the investigation of the fatty oil expressed from them, which was conducted by me and my co-workers in the Wellcome Chemical Research Laboratories.

"A survey of the literature pertaining to chaulmoogra oil rendered it evident that very little of a definite nature was known regarding its constituents, and it was subsequently shown that the so-called "gynocardic acid," which had been stated to melt at 29.5° C. and was employed to some extent medicinally, consisted of a mixture of fatty acids. One of the first results of the investigation undertaken by us was the isolation of a beautifully crystalline acid, melting at 68° C., which was optically active, $[\alpha]_D + 56°$, and found to possess the formula $C_{18}H_{32}O_2$. This was designated *chaulmoogric acid*, with reference to the vernacular name of the oil. It exists in the oil as a glyceryl ester or

glyceride, and represents one of its chief constituents. Although chaulmoogric acid is isomeric with linolic acid, it is capable of absorbing but two atomic proportions of iodine or bromine, and therefore must contain in its structure a closed carbon ring, as has indeed been shown to be the case. A lower homologue of this acid was subsequently found in the oil, and on account of having first been isolated from the oils expressed from seeds of two species of *Hydnocarpus*, viz. *H. Wightiana*, Blume and *H. anthelmintica*, Pierre, it was designated *hydnocarpic acid*. This acid possesses the formula $C_{16}H_{28}O_2$, melts at 60° C., and, like chaulmoogric acid, is optically active, having $[\alpha]_D + 68°$. Many derivatives were made of these acids, including their methyl and ethyl esters, and their constitution was completely elucidated.

"In order to ascertain the character of the oil obtained from the seeds of *Gynocardia odorata*, a quantity of fresh material was specially collected for us in India. The examination of this oil showed it to possess none of the characters of true chaulmoogra oil, thus completely confirming the observations of Sir David Prain respecting the botanical source of chaulmoogra seeds. The gynocardia oil at ordinary temperatures is a liquid, whereas chaulmoogra oil is a soft solid. It is, furthermore, optically inactive, and contains none of the members of the chaulmoogric acid series, but more closely resembles linseed oil in its composition. Both the true chaulmoogra seeds and gynocardia seeds develop hydrogen cyanide in contact with water, showing the presence of a cyanogenetic glucoside. This substance has been isolated from the gynocardia seeds, and is a handsomely crystalline compound, possessing the formula $C_{13}H_{19}O_9N$, which has been designated *gynocardin*. It is accompanied in the seed by an enzyme termed *gynocardase*.

"The literature pertaining to all the above-mentioned investigations, to which several years were devoted, may be found in the *Transactions of the Chemical Society* of London, 1904, **85**, 838; 1905, **87**, 349, 884, 896; 1907, **91**, 557.

"Inasmuch as several articles have recently been published in this country and abroad, chiefly in the medical press, indicating that some new derivatives of chaulmoogra oil have been used in the modern treatment of leprosy, it seems desirable to note that such statements are evidently incorrect. The preparations employed have been the ethyl esters of chaulmoogric and hydrocarpic acids, which were first made and fully described nearly twenty years ago in connection with the investigations above cited. It is the use of these compounds by intramuscular injection, instead of the administration and external application of crude chaulmoogra oil, that has recently led to such successful results in the treatment of leprosy."

Fruit and seeds of the chaulmoogra oil tree were exhibited. One hundred and ten persons were present.

Following the meeting was a social hour with refreshments.

ROY G. PIERCE, *Recording Secretary.*

WASHINGTON ACADEMY OF SCIENCES

The 158th meeting of the Academy, held at the Public Library the evening of Thursday, October 20, 1921, was devoted to a discussion of *Readable Books in Science*, in connection with the list of "One Hundred Popular Books in Science," prepared at the suggestion of Dr. GEORGE F. BOWERMAN by a committee of the Academy and published in the Journal. (**11**: 353–366.

September 19, 1921.) The purpose of the list was discussed briefly by Doctor BOWERMAN, the methods of compilation and editing of the list by Dr. ROBERT B. SOSMAN, the mathematical, astronomical, and meteorological books by Dr. W. J. HUMPHREYS, the mineralogical and petrological books by Dr. E. T. WHERRY, and the botanical books by Dr. H. L. SHANTZ, following which there was a general discussion of the project by several of the previous speakers and by ALFRED H. BROOKS, W. L. SCHMITT, W. D. COLLINS, W. H. BIXBY, and others.

Adjournment was then taken to inspect the following three exhibits: (1) The one hundred popular books; (2) books suggested for the popular list, but not used; (3) books suggested for a proposed list of readable manuals or information books, such as a specialist in one field would recommend to another investigator who was quite unfamiliar with that field.

The 159th meeting of the Academy was held jointly with the Biological Society of Washington and the Botanical Society of Washington at the Cosmos Club the evening of Saturday, November 12, 1921. Professor ARTHUR DE JACZEWSKI delivered an address on *The Development of Mycology and Pathology in Russia.* He was followed by Prof. NICHOLAS I. VAVILOV, who spoke upon *Russian work in Genetics and Plant Breeding.* Following the presentation of these addresses Dr. VERNON L. KELLOGG, Permanent Secretary of the National Research Council, Dr. ERWIN F. SMITH, and others, spoke briefly of conditions in Russia and of the pleasant and mutually beneficial interrelations of Russian and American scientists.

The 160th meeting of the Academy was held at the Cosmos Club, the evening of Thursday, November 17, 1921, at 8:15. Dr. H. D. CURTIS, Director of the Allegheny Observatory, Pittsburgh, delivered a popular address on *The Sun, our nearest star.*

In introducing the subject, the speaker stated two simple equations: (1) Our sun = a star; (2) any star = a sun; which, though simple, are apt to be forgotten when one contemplates the Milky Way. Our own sun is but a unit in a collection of perhaps a thousand million closely similar suns forming our own stellar universe. There are, perhaps, a million other stellar universes, as large as our own and each with a billion suns, within the ken of our great telescopes. Our own sun, though 866,000 miles in diameter, and 1,300,000 times the volume of our earth, is a relatively insignificant star, which, if moved to the distance of the star clouds of the Milky Way, would appear merely as another faint point of light added to the rich complex. The mightiest stars, at their magnificent distances of hundreds or thousands of light-years, appear no larger in our greatest telescopes; for example, Betelgeuse, which in volume would probably contain 27,000,000 globes the size of our own.

The speaker discussed recent studies of the Sun—advances in photography and spectroscopic analysis, and their bearing on unexplained or little understood phenomena; theories designed to account for the peculiar law of rotation of the sun; sun-spots as high-temperature solar storms; their periodicity; the Sun as an almost infinitely old and wonderfully perfect heat-engine radiating heat at a temperature of between 5,000° and 8,000° C., with an energy of about 75,000 horsepower per square yard of sun surface; the age of the Sun, and hypotheses bearing upon the source of the Sun's heat; the wonderful balance of forces existing within the Sun; the correlation between changes in heat emission and terrestrial climatology, and its supremely important bearing upon the origin and maintenance of terrestrial life.

"As we contemplate the complexity of the details of the solar surface, the constant change of form in faculae, spots, and prominences, the balance of forces which has maintained the average energy of the Sun so constant for hundreds of millions of years is certainly a remarkable fact of nature, and lends indirect support to the postulation of an enormous duration of life for the average star.

"In our nearest star, then, we see a star which appears to be about an average star in surface characteristics, light emission, and size. It is a fair representative of the stars in general; there are literally tens of millions of copies of it out in space. This great heat-engine is pretty certainly a billion, and more probably a hundred billion years old. Certainly for 200,000,000 years, perhaps for a billion or more years, it has not varied permanently as much as 200° C. from its effective temperature of perhaps 5,600° C."

WILLIAM R. MAXON, *Recording Secretary.*

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GENERAL SCIENCE.—*Psychophysics as the key to the mysteries of physics and of metaphysics.*[1] LEONARD THOMPSON TROLAND, Harvard University.

I. THE PRESENT PHILOSOPHICAL STATUS OF PHYSICAL SCIENCE

Physical science begins with the naïve man's division of his everyday experience into *external* and *internal* portions. One of these portions comprises for the primitive intellect an external *world* while the other part makes up the man's own personal feelings. The line of demarcation between these two segments of experience seems at first sight to be quite distinct. There are, however, obvious affiliations between components of the two subdivisions of experience. One's own body, as visually or tactually perceived, is a portion of his external experience, but its posture and its movements are normally correlated with internal feelings, this correlation giving rise to the idea of will, or the control of one's own externally perceived body and its relations to the external world, by changes in the internal feelings. The notion of consciousness in other men is at first simply a belief in the existence of further systems of internal feelings which are correlated with the behavior of other externally perceived organisms which resemble in general form, if not in central position, the organism of the given individual.

For the primitive intellect, standing at the threshold of scientific inquiry, physics would undoubtedly be the science of the external world thus defined, while psychology would be the science of the internal system of feelings or of any other similar system of feelings which might be inferred to exist beyond the experience of the given observer. However, as science advances on its quest for knowledge the province of physics in relation to experience constantly narrows, while that of psychology undergoes a compensatory expansion. The naïve physicist looks upon his external experience as being independent of himself because, with the single exception of his own externally

[1] Received Jan. 28, 1922.

perceived organism, it does not immediately follow the dictates of his feelings. This demand, that physics should conceive a universe which is independent for its properties of any particular observer, has been implicitly observed by all physical thinkers down to very recent times. Its actual consequences have been precisely that narrowing of the domain of physics within experience to which I have adverted. The end result, as it appears in the Einstein theory of relativity, seems to have been the complete elimination of the direct data of experience from the domain of physics and consequently a reduction to an irreconcilable contradiction, of the respective demands that physics should be *strictly empirical* and yet at the same time should describe a universe which is *independent of any given experience.*

The first step in the gradual reduction of the physicist's domain within experience involved the accumulation of a long list of so-called *secondary qualities* which constitute what the psychologists now regard as external *sensations.* The qualities which headed this list were naturally those which bore the greatest similarity to the internal feelings which were the initial subject matter of mental science. Under critical examination we find that the external and internal qualities are not so very different after all so that they can be arranged into a nearly continuous series in order of their projicient character. Chemistry at an early date eliminated qualities of taste and smell from its catalog of supposedly actual properties of specific material substances, regarding the gustatory and olfactory characteristics as being merely psychological tests indicative of certain molecular forms of constitution. The theory of heat soon became inconsistent with the existence of two qualitatively opposed thermal elements corresponding with our experiences of cold and of heat, respectively, so that these two distinctive constituents of immediate experience had also to be banished from the domain of physics. The earlier physicists regarded color as an objective property of light or of bodies, but with Newton we find color being treated as a sensation, or as something produced by the organism under the influence of light, which latter in itself is not colored, being not even white or black. With the introduction of the wave theory of radiation, color necessarily and permanently lost its position as a subject matter of physical science, and was relegated to psychology. The wave theory of sound did a similar thing for auditory qualities of pitch and noise. In Helmholtz's two great works dealing, respectively, with physiological optics and

physiological acoustics we find the most eminent physicist of the nineteenth century explicitly treating both color and tone as physiological or psychological entities.

Up to the advent of the theory of relativity (in the twentieth century) it appeared that this process of eliminating the qualitative constituents of external experience from the domain of physics still left within this latter domain three distinctive factors: those of space, mass, and time. The physicist of this period was painstakingly construing all of his data and theories in terms of the centimeter, the gram and the second. These were regarded as being the ultimate physical dimensions, out of which all other physical conceptions must be synthesized. It is true that the developing theory of electricity apparently demanded two other dimensions: those of dielectric capacity and of magnetic permeability, respectively, but these latter conceptions attached more to the *hypotheses* of physics than to its actual measurements. Now from the point of view of psychology or the analysis of immediate experience, space, mass, and time are radically different categories. Only *mass* can properly be regarded as being interpretable as a *quality* of experience. As such it is clearly identifiable with sensations or experiences derived from the so-called *proprioceptors*, or the sense organs of the motor mechanisms of the body, including not only the muscles but the tendons and the joints. It is probable, however, that this feeling of *bodily effort* is more immediately associated with the conception of force than of mass, so that it may be necessary to regard mass as being derived from it by combination with the concept of acceleration, which is a special relationship between spatial and temporal magnitudes. It is of interest that the kinaesthetic quality, which is one of the cardinal constituents of internal experience, should turn out to be about the last directly qualitative experimental factor to remain in the system of physical thinking.

Space, from the psychological point of view, may in some cases be regarded as forming a distinctive qualitative constituent of consciousness. There are sensations for example which possess a spatial or extensive quality while others are lacking in this attribute. In the majority of instances however we are forced to regard space in experience as representing a *form of combination* of elementary qualities rather than as comprising such a quality in itself. In this sense space is a category of *structure* rather than of substance. Visually perceived

surfaces for instance are to be regarded as concatenations of color elements, which latter in themselves cannot constitute any surface, however small. On the other hand, the impression of empty space separating the eye from the color surface must be regarded as involving a distinctive visual element of depth, which cannot be identified with color; these depth elements, however, are in themselves non-structural and must be arranged into a structure in order to present an experience of distance or of volume. Now, it is clearly the structural rather than the substantial aspect of spacial experience which physics considers. The physicist arranges his units of mass in imagination into a three-dimensional pattern which is structurally similar to the arrangements of qualities, such as color or touch sensations which he finds in immediate experience. The similarity however, is not complete, since none of the spaces, visual, tactual or auditory, of our consciousness are strictly Euclidean in character. They are all more or less anisotropic or possessed of different properties in different directions, and they are obviously very imperfect and incomplete in relation to the totality of the universe.

The category of *time*, again, is psychologically quite distinct in nature from those of mass or of space. Time is not qualitative, neither is it structural, for it concerns quite another aspect of experience, namely its liability to *change*. The idea of time is inflexibly bound up with the fact that experience is a process or a flux. This flux consists in the replacement of one form of consciousness by a different one. Within consciousness or experience in concrete form such processes involve transmutations not only of structures but of qualities. Physics, however, having eliminated the latter, must confine itself to changes in spacial structure, or to motion. Time, for physics, thus becomes a conception of the relation between motion and the thing which moves; in any single instance it is measured by the ratio of a distance to a velocity, a definition which must be supplemented in situations involving a multiplicity of concurrent motions, by a definition of *simultaneity*. Time, both from a psychological and from a physical or mathematical point of view, is a complex conception based upon two ultimate facts: those of change and of the interdependency of concurrent changes.

Although the relations between the space, mass and time concepts of physics and the corresponding conceptions relating to immediate experience are clearly somewhat involved, it was nevertheless possible

for a philosophically uncritical physicist prior to the advent of relativity theory to regard his subject matter as an actual abstraction from immediate experience. I say "philosophically uncritical" because even before the advent of the Einsteinian theory a very close scrutiny of the relations obtaining between physical ideas and the actual data of consciousness would have revealed serious difficulties in their identification at any point. These difficulties were manifest to Bishop Berkeley, several centuries ago, when he wrote his essay on A New Theory of Vision and maintained that the primary as well as the secondary qualities of external experience could not be regarded, as required by the physicist's formula, as being independent of the observing individual. If the structures and the changes of physics differ ever so minutely from those which occur in the experience of the observer they cannot be identical with the latter, and must therefore be conceived as comprising a separate though possibly a very similar system of things. It is doubtful whether even with the assistance of the notion of universals, or of platonic ideas, we can legitimately conceive even absolutely similar structures as being numerically identical, if the substances which enter into these structures are different in kind. The fact that our perceptions of spacial, massive, and temporal relationships are conditioned, as was emphasized in Berkeley's classical monograph, upon physiological processes is not in itself proof that these perceptions do not actually include portions of the physical universe. However, the neo-realistic philosophies which explicitly assume this possibility have not as yet succeeded in developing an explanation of the universe which is either simple or plausible.

The acceptance of the principle of relativity settles this dispute within the domain of physical methods alone by admitting that measurements within all three of the fundamental dimensions of physics are conditional for their objective significance upon the conditions of observation. In accordance with the Einsteinian scheme, two observers can make measurements upon what purports to be a single object or system and these measurements may be quite discrepant without either set of evaluations constituting evidence superior to the other; in other words, what any individual observer empirically finds, using the most refined methods of physical analysis and restricting himself to the domain of space, mass and time, is still dependent upon his own standpoint and does not comprise the only true description of external realities. Whether an object is long

or short, or a period of time protracted or brief, depends upon the rate of motion of the observer with respect to the system which contains them, and since there is no criterion of absolute motion, one observer's results are as good as those of any other. The ultimate units of physical science are shown to be purely relative to the conditions of their establishment. Such are the assumptions which are necessary to the simplest and apparently the only plausible solution of the conflicts between the systems of physical data which have developed from astronomical, optical and electro-magnetic observations. In this situation we see the purposes and the facts of physics itself driving the physicist into a repudiation of the last scrap of empirical meaning which it would be possible otherwise by the greatest effort of imagination to read into his system. Thus, in spite of the realism of the naïve and materialistic mind, does psychology at last fall heir to the whole of its natural estate: the totality of immediate experience.

What under these circumstances may we consider to be the estate of physics? Physical formulae, although robbed of their empirical meaning, nevertheless purport to describe a permanent external system of things. How shall we conceive the intrinsic nature of this external system and what exactly are its relations with the system of immediate experience? If space, mass and time, as we ordinarily conceive them, cannot be supposed to exist in this objective physical system, it is still possible that fundamental dimensions of a different character may exist and be such as to resolve the conflict between the results of separate observers formulated in ordinary C. G. S. terminology. Minkowski's symbolic scheme in which time is made a fourth dimension—coordinate with the three dimensions of space—suggests a system of this sort but is not the only alternative nor is it a very intelligible one.

This is the mystery into which modern physics has led us. The problem of the nature of the external universe which physics set out to solve has virtually been abandoned by the physicist, for his present-day description of the universe is couched in terms and in a form to which we can assign no direct empirical meaning. He provides us with the logical skeleton of a system which has no living tissue. What can we do to bring this skeleton to life? In this situation it seems that physics itself can provide us with no further assistance and it is therefore necessary to turn back to the sister science, psychology, whose

domain has expanded within experience as that of physics has perforce contracted. The data of psychology and the facts which relates these data with the physical system, in psychophysiology, may provide us with a clew to the mystery.

II. THE INTERRELATION OF CONSCIOUSNESS AND RESPONSE

When the physicist rejects from the domain of his science a quality of immediate experience, he ordinarily substitutes for it in his system some physical conception expressible in C. G. S. terms. For example, pitch is replaced by a certain frequency of vibration of material particles, while color finds its substitute in very much higher frequencies of electro-magnetic oscillation; hotness and coldness are replaced by certain ranges of kinetic energy of molecular vibration. These surrogate physical conceptions turn out for the psychologist to be the *stimuli* of the respective qualities, when the latter are regarded as sensations. However, these *stimuli* do not operate directly upon consciousness, or immediate experience, but rather upon the physiological organism, taking effect at certain sense organs or receptors which are differentially tuned to respond to various forms of physical activity. Pure introspective psychology is compelled to restrict itself to the analytic description of immediate experience, but psychology in general or at large inevitably becomes involved in a study of the relationships existing between immediate experience and the living organism. This organism is throughout essentially a conception of physical science, it being the creed of mechanism or of anti-vitalism in biology that all organic structures and processes can ultimately be reduced to physico-chemical constituents. Biology, like chemistry, is in other words, simply a special department of physics dealing with the properties of particular complex physical structures.

We are all familiar with the fact that the modern physicist conceives the ultimate substance of all physical things and processes to be what he pleases to call *electrical*. Electricity, positive and negative, is the fundamental mass-carrying entity of the physical universe, and all actions or interactions are ultimately the expression of electrical, or of the correlated magnetic, forces. If living organisms are simply aggregates of chemical molecules and if such molecules are simply definite congeries of atoms, and if atoms furthermore are nothing but constellations of protons and electrons; then fundamentally organisms are simply vastly intricate structures of these ultimate electrical units and organic functions are wholly reducible to the com-

plex interplay of the electromagnetic forces which are associated with these physical particles. The fact that the intrinsic nature of electricity is not specified by physics, which rests content with its definition in terms of its external dynamic relationships, is merely a further aspect of the general inability of physics to describe its universe in imaginable terms. However, our ignorance of the nature of electrons and protons in and for themselves does not prevent us from ascertaining and describing the structures or processes into which they enter.

The psychologist, as a psychophysiologist, discovers that consciousness is at least in part representable as a *mathematical function* of certain aspects of organic structure and activity. Each individual consciousness appears to be determined by the nature and reactions of a particular corresponding physiological mechanism. There are as many fields of consciousness, or streams of experience, as there exist living organisms, in particular human organisms. It seems to naïve observation and thought as if consciousness were a product of the organic mechanism, as well as if it were capable in turn of influencing that mechanism. This is the doctrine of "interactionism" in psychophysiology. However, the difficulty of conceiving a transfer of energy from the physical organic system to consciousness or the reverse is so great that the majority of psychologists prefer the doctrine of psychophysical parallelism according to which a functional or determinative relationship obtains between the two systems without either being regarded as causally dependent upon the other. That this is an unsatisfactory doctrine may be freely admitted, but upon a level of philosophical argument which (erroneously) regards the psychical and the physical systems as of coordinate reality it cannot be avoided.

The first aspect of the functional relationship between consciousness and physiological factors which becomes available to the psychophysiologist is that which obtains between sense qualities and stimuli. We have noted previously that when the physicist ousted color from the domain of his science he substituted for it, electro-magnetic waves of certain specified length, and since the latter are conceived to be portions of the physical world while the former are now considered as psychological entities merely, this act of the physicist at once establishes a definite psychophysical relationship. From the point of view of the physicist, color and wave-length are simply associated

factors in the external environment of the organism, but the psychophysiologist soon finds that the association is brought about purely through the medium of factors lying within the organism. He finds that electro-magnetic wave-lengths entail the existence of color only if they are acting, or are capable of acting, upon the retina of the eye, and moreover only if the resulting stimulation of the optic receptors is followed by a nerve current set up in the optic fibers and even then only if this current is permitted to flow into the higher nerve centers of the cerebral cortex. A still closer study of the facts shows that the intraorganic factors in this process are apparently more essential than are the stimuli which constitute the physicist's substitute for color. The actual colors which are aroused by given stimuli depend radically upon the condition and the biological type of the stimulated nervous system, and conditions are readily found under which colors appear in the entire absence of a sensory stimulus, and indeed even without the assistance of any current within the optic nerves. What is true of color in these respects holds equally for all other sensory qualities. But this is not all. The same considerations appear to apply also to the primary qualities of space, mass and time in so far as they are given in the immediate experience of any individual. In a word, *immediate experience in its totality is determined by the operations of the nervous system.*

The typical plan of a nervous process is that of what we may call the response arc. Physically considered, neuro-muscular response is merely a special, very intricate, example of the *propagation* of physical disturbances along a restricted *conduction* path. The process consists of a series of stages following each other in space and in time, each depending for its exact character in part upon the nature of its predecessor and in part upon the particular elements in the nervous mechanism which are carrying it. The characteristic successive stages of a response process may be listed as follows: (1) the physical object, (2) the stimulus, (3) the sense organ process, (4) the receptor process, (5) the afferent nerve stimulation, (6) the afferent nerve conduction, (7) the central synaptic process, (8) the efferent nerve conduction, (9) the end plate process, (10) the effector process, (11) the effect. This chain of events, starting with the environment and leading back to it again, is conceived to be physically complete, at no point involving the intervention of any psychical activity.

Now it happens that at the present time there is a slight disagree-

ment among psychologists as to exactly what selection of these various stages of the response process will show the closest correlation with the facts of immediate experience. However, these differences of opinion appear to rest more upon a quest for novel viewpoints, than upon any new data which actually contradict the classical teaching that consciousness in its entirety is correlated directly with the *central* or synaptic process alone; for the simplest explanation of all of the relations which are discovered by the psychophysiologist appears to lie in the idea that the whole of experience, both external and internal, is a function of certain restricted nerve processes occurring probably in one of the association areas of the cerebral cortex. The correlations existing between experience and other stages in the response are, according to this view, indirect in nature, resting upon the purely physiological interdependencies of all of the stages in question.

If we accept this truly astounding principle of the "monophasic cerebro-cortical determination of consciousness" the problem of psychophysiology reduces itself in essence to a study of the laws which relate the component variables of consciousness with those of the cortical mechanism. So far very little which is definite has been established along this line, but the simplest working hypothesis would appear to be that there exists a point-to-point correspondence between the constitution of immediate experience and that of the cortical activity so that for each distinctive characteristic of experience or consciousness there is a corresponding attribute of the brain activity. This is the specific form which the general doctrine of psychophysical parallelism assumes under the influence of the monophasic cerebro-cortical theory. The structures of consciousness, in harmony with this view, would probably depend upon the structural interconnections of various active brain elements; the unity or coherence of consciousness would be correlated with the electrical continuity of the fields of excitation which make up the cortical synergy while the various qualities which form the substance of consciousness would presumably be determined by the varieties of *atomic or molecular* structure to be found in the various cortical synapses.

III. THE METAPHYSICS OF THE PSYCHOPHYSICAL RELATION

Having considered the outcome of sophisticated reasoning in the domains of physics and of psychology, let us return once more to the point of view of the primitive intelligence with which we began. Let each one of us, for the moment, identify himself with this in-

telligence. I will speak in the second person to enforce the realism of the argument which is to follow. At the start you, the naïve thinker, divided your total experience into internal and external sections, assigning the study of the former to psychology and of the latter to physics. At first you regarded the whole of your external experience as forming part of a world which existed independently of your experience, but as you progressed in your physical thinking you found that more and more factors in your external experience failed to measure up to the demands of this belief and hence had to be rejected from the subject matter of your physical science. Eventually you retained only space, mass, and time, substituting complications of these for all other empirical factors, but then Einstein appeared upon the scene and proved to you that these also could not be conceived to exist unmodified apart from your own experience. You then found yourself in the predicament of having built up a highly specific and intricate logical system, to the component terms of which you could no longer attach any imaginable meaning. This logical system, written in symbols in your books, still purported to refer to a real external universe, but what that universe could be like in itself was a question which you now found yourself quite unable to answer. To say that its ultimate substance is electricity would merely be to confess implicitly that, although you knew something *about* it, you knew nothing at all *of* it.

In this situation you seem about to admit your complete ignorance of the nature of *any* reality apart from your own immediate experience. But if you will ponder a moment you will find already resident in your thought a very potent belief in the existence of certain realities apart from your experience, but realities which are, in general, quite different from any part of the physical world. The realities in question are the consciousnesses, or experiences, of *other men*. These you suppose to be similar in character to your own consciousness but nevertheless to be quite separable from the latter and to be entirely independent of it for their continued existence. In order again to lend realism to the argument I will take as an example of other consciousness my own experience contrasted with yours. Suppose now that, having become interested in consciousness, you become a psychophysiologist and work out the relationship which must be conceived to exist between my consciousness, or experience, and your symbolic physical world. You will find, as we have seen, that my

consciousness is correlated point for point with certain physical structures and processes occurring within a very restricted portion of your physical system which you call my *brain process*. This physical brain process of course you cannot for a moment conceive to exist apart from your own consciousness and even here it will ordinarily have only symbolic or logical existence; you think, talk and write about it a great deal but, except in the rare instances where you happen to be a brain surgeon and I happen unfortunately to be your patient, you never come anywhere near seeing it. But even if you were actually to perceive my brain process in all of its molecular detail you would not dare to affirm its external reality any more as a system of C. G. S. quantities than as an arrangement of color surfaces in space. Yet you do believe firmly that your conception of the structures and processes of my brain does, like the remainder of your conceived physical universe, correspond with *some* reality external to your experience the logical constitution of which is closely similar to that of your physical scheme.

Under these circumstances can you not most assuredly be convicted of intellectual incapacity if you do not recognize in *my consciousness itself* a perfectly good reality which may constitute the actual meaning of your physical symbol called a brain process? In your ultimate philosophy of physical science you affirm that all of your physical equations stand in point to point correspondence with an unknown reality. In your interpretation of the data of psychophysiology you affirm in the doctrine of the parallelism between consciousness and the brain process that my individual experience stands in exactly this relation to a certain part of your physical system. Why, then, should you not admit that my experience *is* the reality towards which this particular section of your physical system has always been pointing?

This is a doctrine which is easily heard but which is very difficult to see. It *rhymes* with the evidence, but yet it seems to conflict too much with common sense; with common sense physics and with common sense psychology. We have too long considered mind and matter to be two irreconcilably disparate but nevertheless interacting entities; matter a substance and mind an intangible activity. Now we are required to treat mind as if it were a substance and to identify it with the reality of matter. The doctrine is apt to cause much confusion in our thoughts because it turns all of our old mental furniture

topsy turvy. Nevertheless, if it is accepted and its implications followed it will be found to clarify and to simplify our entire conception of the universe. It can solve, firstly certain profound mysteries into which we are led by modern physics, the mystery of electricity, the riddle of relativity, and—I am inclined to believe—the enigma of the quantum theory; secondly, it will obliterate the dualism of mind and matter by actually explaining the relation of psychophysical parallelism upon a monistic basis; and thirdly it will provide us with an organon for the systematic and rational study of the real universe which lies beyond our own individual experiences.

A theory possessing powers such as we have just alleged should be expected, once it was clearly formulated, to take the philosophical world by storm. Sad to relate, this expectation seems doomed to disappointment. The father of psychophysics, G. T. Fechner, stated the doctrine in principle in 1863. W. K. Clifford rediscovered it in 1878. Alfred Barrat evolved practically the same doctrine in 1883 but his book seems quite unknown to any other writers on the subject. Independently in 1885 it was evolved by Dr. Morton Prince. But in 1903 and 1905 it was elaborately expounded practically without reference to previous expositions, by C. A. Strong and G. Heymans, respectively. Only two English speaking psychologists, Stout and McDougall, have taken any cognizance of the doctrine, although it eliminates difficulties concerning the discussion of which psychologists have wasted thousands of pages of manuscript. I worked out the theory myself in great elaboration, probably from suggestions contained in Paulsen's Introduction to Philosophy in my undergraduate days. Heymans' book, which appeals to me as being the keenest discussion of metaphysical problems which I have ever read, appears to be entirely unknown in the department of philosophy at Harvard and at no time during my own study in that department do I remember having heard the theory of psychical monism mentioned even casually.

The failure of the doctrine to take root in the minds of philosophers and psychologists is due I believe to their habitually fuzzy methods of thinking. It is a doctrine much better adapted in form to the mathematical mind of the physical scientist. But although the form will suit the physicist the substance unfortunately probably will not do this. Here, again, it may fall upon barren soil, but I am trying the experiment of sowing it there now.

IV. THE PSYCHICAL MONIST'S UNIVERSE

In order to show how our hypothesis may possibly accomplish some of the great things claimed for it, we must elaborate its implications in further detail. Let us adhere to the use of the second and first persons as before to make vivid the situations which are involved.

You must begin your thought with the assumption that the reality lying behind your idea or perception of my cerebral process is simply my total introspective consciousness. The various material or dynamic components which you perceive or conceive within this brain mechanism are merely the individual representations within your own consciousness of these components of my consciousness. Each element in your picture of my brain process is in reality simply an element of your own consciousness, but it may be considered as an *effect or product*, however remote, of the action of a corresponding, but ordinarily quite different, element in my consciousness. The structure of the brain process is but the reflection in a psychophysical mirror of the structure of consciousness; although it is a product not so much of optical as of philosophical reflection.

It should be clear to you at once that this hypothesis quite resolves the dualism of mind and matter and provides a real explanation of the psychophysical relation. It destroys the dualism by dethroning matter from its exalted seat as a peer among substances with mind. Matter, or electricity, is denied existence except in so far as it is actually presented within any given concrete field of experience, but within such a field it cannot be the matter concerning which physics speaks and can only constitute psychological matter or specific perceptual complexes of sensory qualities. Hence in so far as our doctrine of psychic monism admits the existence of matter, it classes it as a subdivision of consciousness. The physical systems which we are considering in our discussion of the brain process, however, do not even have this degree of reality, since all that is presented in consciousness at the moment of discussion are complexes of visual or auditory sensations or images which are commonly called words. These words, it is true, are supposed to have meanings, but the meanings are by hypothesis not regarded as being within consciousness, and hence we are quite at liberty—so far as the evidence of immediate experience is concerned—to deny their existence altogether.

When we see thus clearly what is actual and what is possibly only fictitious in the psychophysical relationship we recognize that this

relationship as ordinarily conceived holds between any individual consciousness and the non-existent meaning of a physical scientific description. The only parallelism of reality is between the conscious system and the descriptive system, but the descriptive system employs, in general, terms which are not suitable to the nature of consciousness. The psychical monist suggests that this is an error, the description having actually been determined in its logical form by unrecognized influences emanating actually from the given consciousness, so that the tangled threads may be straightened out simply by substituting in the description, terms and elementary relations which are appropriate to psychical manifolds in general. The explanation of psychophysical parallelism which is afforded by psychical monism is therefore analogous to one which would show why the shadow of a man should follow him about and be roughly similar to him in contour and gesture. Both the shadow and the man are integral parts of a homogeneous system, but they happen to enter into a peculiar relationship—not at all characteristic of the structure of the universe as a whole—in which there is an apparent parallelism of parts and of activities. The psychical monist's explanation of the functional relationship which psychophysiology finds to hold between consciousness and the brain process is every whit as good as is the physicist's explanation, within the domain of optics, of the relationship which obtains between object points and image points in reflecting or refracting systems. The exact physical counterpart of the explanation, however, is to be found in the relation existing between the object and the brain process in the mechanism of response; for the exact physical picture of what is happening when my consciousness is acting upon yours is given by my brain process becoming the object in the response propagation, which culminates in your brain process.

The psychical monist, however, has not finished when he has dissipated the mystery of psychophysical dualism. He must go on to consider the larger psychical universe which lies beyond your particular consciousness or mine. Since the facts of psychophysiology indicate that my introspective consciousness correlates with only a small portion of what you perceive or conceive as my physiological organism, the question obviously arises as to what significance can be assigned, in the universe external to your consciousness, to the *remainder* of my organic structure and processes as conceived by you. In the first place, you may consider the fact that not my total nervous

system nor even the whole of my cerebral activities are apparently associated with the immediate production of my introspective consciousness, but only a restricted area of the cerebral processes. How shall you interpret the immediately outlying cortical activities? I might answer that these are probably the results of your attempt to conceive physically a reality which I call my *subconscious mind*. Some psychologists have experienced a great deal of difficulty in conceiving the subconscious mind actually to be conscious. But from the point of view of psychical monism this is a very easy thing to do. Consciousness is treated as a qualitatively differentiated substance which is capable of forming systems of greater or less complexity and of varying degrees of coherence. Just as your consciousness and mine are both conscious yet not mutually inclusive nor even, it would seem, connected in any conscious way, so my introspective field of awareness and various depths of the subconscious may all be conscious without being co-conscious or uniting to form one integral coherent system.

If you follow this line of thought with regard to what may be called the psychical environs of my introspective consciousness you will be led to believe that my consciousness is psychically surrounded by a system of psychical entities or processes bearing the same relationship to it that the brain processes which envelop the central cortical activities bear to the latter. For every neurone in the nervous system and for every atom in each neurone there must be a real psychical fact which is related to my consciousness just as my neurones and their atoms are related to my central brain process. My field of introspective consciousness must, in other words, be considered the focus of a vast psychical nervous system, a nervous system made not of protons and electrons but of atoms of sentiency. Within this system there transpire propagations of influence converging upon and diverging from my introspective field which correspond exactly with the neuro-muscular response processes which you picture to yourself when you are thinking of the operations of my nervous system physically. Your physical conception of this response is indeed clearly nothing but a symbolic representation of the real psychical response system, which is of a sort which was functioning in connection with the consciousness of primitive man before any of the conceptions of modern physiology were even dreamt of.

You cannot stop here, however, you must go on to consider the

meaning of the non-nervous portion of my organism as you conceive it, and, furthermore, the significance of the world of physical stimuli and objects which surround it. The intra-organic stages of response are merely certain links in a continuous chain of influences which flow into the organism at the sense organs and out of it at the effectors, and the nervous mechanisms of the organism differ only quantitatively from those of other tissues. The continuity of physical nature commands that you expand your conception of the psychical universe into a structure which corresponds point for point not only with the parts of my nervous system but with all the constituents of my organism and of my environment; indeed, with the totality of the physical universe as conceived by the most comprehensive physical mind. You are thus led to the conception of a complete universe of objective consciousness, the formal structure of which is substantially identical with that described by the physical sciences of biology, geology and astronomy, but the substance of which is similar to what the psychologist finds in immediate experience. The processes of this great psychical world, being—like those of the physical system—mainly a succession of different structures, must also be formally identical with those which the physical scientist describes. This inference from the general homogeneity and continuity of the physical system which embraces my brain mechanism, therefore leads you to a rational and meaningful interpretation of your entire physical hypothesis. It is this psychical universe at large, in which my consciousness and also your own are small but integral parts, which constitutes the real objective meaning of the relativity C. G. S. electro-magnetic schema in general physics.

Certain apparent difficulties which arise in connection with this doctrine can readily be shown to be specious. In the first place there is the difficulty of conceiving consciousness or the psychical as a self-existent substance which is capable of forming definite structures. This difficulty arises from an adherence to the idea of consciousness as a relation between a self or ego and an object, whereas modern introspective psychology quite rejects this conception, along with that of the ego, and identifies consciousness with the mosaic of sensory and other qualities which were regarded as contents or objects of consciousness in the older, relational theory. Consciousness, for the modern psychologist, is essentially a mosaic which must be analyzed into elementary qualities and their interrelations, so that pure intro-

spective psychology is often designated as structural psychology. That the qualities and the structural coherences of consciousness are capable of existing in their own right is certainly a reasonable supposition, since the very idea of existence must inevitably rest upon the demonstrable reality of these data of experience. Another similarly specious difficulty appears in the persuasion that the panpsychic extension of consciousness to correspond not only with brain processes but with all material systems makes the universe unduly complex; so that the doctrine seems liable to succumb to the onslaughts of Occam's razor. This objection is specious because psychical monism, unlike dualistic panpsychisms, does not *add* consciousness to the equation of matter but substitutes it within this equation. The resulting system is therefore of exactly the same degree of complexity as that of physical science and the latter has vanished from the metaphysical arena completely, appearing now merely as stage of reasoning—like those of pure mathematics within physics alone—leading up to the final account of things. The psychical monist's system is, as a matter of fact, much simpler than any materialistic scheme which acknowledges all of the data of experience, for all such schemes inevitably demand dualism and reduplication of factors wherever the existence of consciousness can be demonstrated. For psychical monism, on the other hand, all demonstrable fields of consciousness are merely interlocking parts of a system which in its totality is no more intricate than a materialistic system which excludes all considerations of consciousness.

In reality, the complete psychical system is probably even simpler than this. The physicist thinks of each component electron or proton in his system as retaining its discreteness or individuality regardless of the relations of combination into which it enters with others. Synthesis, for the physicist, is not of the elements themselves but only of the structures, which are condensed in space and increased in stability. There is convincing evidence, however, that atoms of mind-stuff do not behave in this way, and that when they combine they actually fuse—in varying degrees according to circumstances and partially—or, in the limit, wholly—lose their identity. Such fusion results in the generation of a new over-all "form quality" of the resulting integral which is the conservation index of or compensation for the sacrificed discreteness of the combined elements. This is real synthesis, and while it increases the qualitative diversity of the

components of the universe, it greatly simplifies its structure. The necessity for a principle of this sort operating in the psychical universe first appears in a consideration of the relations between so-called elementary components of experience—such as any point sensation of color—and the corresponding brain components. Although the former seem simple the latter must almost certainly be complex. There are only two kinds of ultimate physical elements, positive and negative electricity, while there are thousands and probably millions of qualitatively distinct, irreducible, elements of consciousness. Clearly these psychic units cannot correspond to protons and electrons or even to specific chemical elements, but must be correlated with molecular, colloidal, or crystal species.

Here the parallelism of structure between the physical and the psychical systems appears to break down; only in the grosser and more disperse organizations of matter can it be conceived to hold at all rigidly. Possibly there is some slight degree of structure in so-called elementary qualities, but not enough to arouse an analytic judgment. At any rate we may suppose that when such qualities decompose, as in the analysis of a musical chord or clang, they always yield definite end products in a definite structural relation, so that they may always be said to have potential structure. Physics derives its physical diagrams of the constitution of these finer parts of its universe almost entirely from a study of the ways in which they can be formed or the manner in which they break down, and hence may be accused of reading into them an exaggerated structurality. In terms of given existence rather than of history or prophecy, however, the translation of physical space structures into psychical realities will involve the transmutation of an increasing fraction of structurality into specific quality, as the physical mosaics become more cohesive and in general more microscopic.

These considerations indicate that although the technique of physical thinking—according to our interpretation—is implicitly aimed at a determination of the abstract structure of the psychical universe, this technique is not as yet perfectly adapted to that purpose. In regard to structure, it overshoots the mark. In other ways, it may introduce into the physical scheme of concepts, artifactual terms and relationships, which have the same irrelevancy to the real universe which the surds and irrational numbers of mathematical technique have to the physical scheme by itself. Considerations of this sort

may throw light upon certain mysteries of modern physics, such as the quantum theory of energy transfer. This conception of atoms of activity which seems absolutely essential to the explanation of known laws of the emission and absorption of radiant energy appears to be squarely in conflict with phenomena of the interference type upon which the continuous wave hypothesis was founded.[1] Is it not possible that this quantum conception—like the irrationality of π—is attributable to an artificial incommensurability of the present concepts of physics and the properties of the real universe? An inkling as to the nature of this incommensurability is given by our considerations regarding the reality of psychical synthesis. If the physicist overestimates the discreteness of the various parts of the universe, he may find it necessary to compensate for this by overestimating the discreteness of the changes which occur within or between them. His changes are fundamentally expressed as ratios of spaces to times and an erroneous factor in the structural numerator of this ratio could therefore be canceled in its influence upon conclusions by an equivalent, erroneous factor in the temporal denominator. We might explain the introduction of this latter factor by the hypothesis that the local time of any single radiator is atomic or possessed of a cell structure so that successively emitted quanta, although distributed at random within these cells would be held in constant phase from the point of view of a receiver, by always beginning at the front end of a given time cell, and on the average filling large blocks of such cells homogeneously. But this would merely be another outrage to our common sense ideas and a further indication of the unreality of the physicist's schema.

It is along similar lines that the psychical monist rationalizes the principle of relativity. This principle immolates the stability of empty space and time to the constancy of the velocity of light under all conditions. But the psychical monist sees at once that empty space and empty time have no objective meaning whatsoever. In the psychical universe, space has significance only for the form of combination of concrete psychical units. Where such concrete units are absent there can be no form of combination and hence only non-

[1] This paragraph was written from the point of view of J. J. Thomson's "pulse theory" which renders understandable the mechanism of emission and absorption of quanta. The more current idea of a quantum as a short train of continuous waves fits in better with interference phenomena, but in doing so simply places the paradox in a different place, in the processes of emission and absorption.

existence. The same is true of time, which is merely an aspect of concrete changes and their functional interrelations. Such interrelations are symbolized physically by the transfer of radiation, and the velocity of this transfer is thus the natural reference constant for the establishment of standard temporal and structural systems. Although we may not be able from these considerations immediately to deduce the Einsteinian equations, we can at least recognize that the psychical monist's universe is sufficiently different from that of non-relativity C. G. S. physics to make it possible for the equations in question to fit its properties without inconsistency.

In conclusion a word must be said concerning the relation of the psychical monistic hypothesis to the philosophical discipline known as metaphysics. This discipline has several subdivisions, such as epistemology and ontology, but one of its main efforts has always been to determine the inherent nature of reality, and in particular reality independent of individual experience or merely "phenomenal" representations. For every phenomenon it has tended to postulate a "noumenon" or a thing-in-itself. Physics, as I have interpreted it, clearly has a strong metaphysical inclination in this respect, but only materialistic metaphysics has accepted physics as actually answering the metaphysical, or the "metempirical" question. Metaphysicians other than the materialistic ones have in general worked entirely by arm-chair guesses or have employed idiosyncratic methods, such as Hegel's principle of thesis, antithesis, and synthesis. Now, psychical monism very evidently steps into the metaphysical arena with a definite theory of the general nature of things in themselves; but it does more than this, it brings with it a sword with which to engage in the metaphysical fray of words: a definite method of research.

This new method or "novum organon" for metaphysics consists simply in determining carefully the laws which link the factors of human consciousness with those of brain function and then generalizing these laws so that they can be applied not merely to brains but to any physical structure or process whatsoever. The possibility of doing this rests upon the continuity of nature and upon the belief that human consciousness is sufficiently complex to exemplify all of the elementary psycho-physical relationships. It is the principle of the "flower in the crannied wall" from a careful study of which we can infer the constitution of the entire universe.

If time permitted we might go on to apply this method at least

in a preliminary way to see to what specific depictions of the general psychical universe it may lead us. However, I can here only express my belief—justified by theoretical results already achieved—that the doctrine of psychical monism will not only throw light upon the mysteries of physics and of metaphysics but also upon those of religion and of ethics. When we know exactly what manner of universe we live in we shall know whither that universe is going and what our own part must be in its evolution.

PARTIAL BIBLIOGRAPHY

BARRATT, M. A. *Physical metempiric.* London, 1883.

CLIFFORD, W. K. *On the nature of things in themselves. In lectures and essays.* London, 1878, **2**: 52–73.

HEYMANS, G. *Einfuhrung in die Metaphysik auf Grundlage der Erfahrung.* Leipzig, 1905, pp. 218–321.

PRINCE, M. *The nature of mind and human automatism.* Philadelphia, 1885.

PRINCE, M. *Hughlings-Jackson on the connection between the mind and the brain.* Brain, 1891, **14**: 250–270.

STOUT, G. F. *Manual of psychology.* London, 1907, pp. 34–56.

STRONG, C. A. *Why the mind has a body.* New York, 1903.

TROLAND, L. T. *Paraphysical monism.* Philosophical Review, 1918, **27**: 37–62.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

161ST MEETING

The 161st meeting of the Academy was held jointly with the Botanical Society of Washington at the Cosmos Club, the evening of Thursday, December 15, 1921. Dr. WILLIAM E. SAFFORD, of the Bureau of Plant Industry, U. S. Department of Agriculture, delivered an illustrated address upon *The food plants of Ancient America.*

Every food staple encountered by the early explorers and colonists of America was new to them. Not a single Old World cereal, vegetable, fruit or root-crop, had found its way to this continent before the discovery. American agriculture, as practiced in various regions both north and south of the equator, was endemic. The cultivated food staples had been won by the Indians from wild shrubs and herbs: maize from a wild grass; squashes and pumpkins from wild gourds; common beans and lima beans from leguminous vines scrambling in thickets; potatoes from a tuberous weed of the Andes; sweet potatoes from one of the many wild morning-glories; peanuts (*Arachis hypogea*) from a wild vine that ripened its seeds under ground; tomatoes and capsicum peppers from solanaceous plants of the hill-sides and plains; pineapples from coarse prickly-leaved plants of certain semi-arid regions of Central America; chocolate from the seeds of a tropical American shrub; and tobacco from several species of clammy ill-smelling weeds allied to the narcotic henbane of the Old World.

The very early dissemination of some of these plants led to conflicting theories as to their origin. A recent writer, unhampered by botanical knowledge, declares that tobacco and several other well known American economic plants were brought to America from the Old World. He stigmatizes Columbus and his companions as liars, and modern ethnologists as fools. Even botanists have advanced erroneous theories regarding the origin of well-known food plants, one of the authorities on the gourd family, for instance, declaring the squashes and pumpkins of America to be of Asiatic origin. De Candolle himself was governed too much by acounts of early travellers, which were often vague and unsatisfactory. Owing to such accounts, the South American potato (*Solanum tuberosum*) has been confused with the openauk, or ground-nut, of the Virginia Indians (*Glycine apios*), which the early French colonists called "racine á chanelet;" and the peanut (*Arachis hypogea*) has been confused with the North American ground bean (*Falcata comosa*) and the African *Voandzeia subterranea*, both of which have subterranean fruits. Other examples are the confusion of the American *Cucurbita maxima* and *C. pepo* with Old World gourds. Fortunately we have an abundance of material from prehistoric graves, including remarkably well preserved fruits, seeds, and tubers of food plants, as well as beautiful reproductions of the same in the form of funeral vases of terracotta.

Among the food products shown on the screen were specimens of maize from ancient graves and burial mounds of South and North America; seeds, shells, and stems of squashes and pumpkins, and beautiful reproductions of *Cucurbita pepo* and *C. maxima* in terracotta; many distinct varieties of *Phaseolus vulgaris and P. lunatus;* actual specimens of *Arachis hypogea* in a remarkably perfect state of preservation, and terracotta vases incrusted with peanuts modeled from the fruits themselves; specimens and models of potatoes (*Solanum tuberosum*), sweet potatoes (*Ipomoea batatas*), mandioca (*Manihot utilissima*), and dichotomous roots of *Canna edulis*. Some of the models were in the form of idols, one of the squashes having the figure of a god mounted upon it, and a canna root having also a human head depicted on the principal root. A corn god surrounded by ears of maize was in the form of a monster with great tusks protuding from the mouth; a terracotta figure, evidently the god of agriculture, held in one hand a stalk of maize bearing ears and tassel and in the other a stalk of mandioca bearing a fascicle of fusiform roots. Many of the specimens shown were from collections made by the lecturer while exploring in South America.

Lantern slides of wild fruits, tubers, and edible roots were also exhibited including the principal species used by the Virginia and New England Indians, and wild grapes from which the Concord, Catawba, Niagara, and other well-known varieties of cultivated grapes have been developed in modern times.

WILLIAM R. MAXON, *Recording Secretary.*

ENTOMOLOGICAL SOCIETY

337 MEETING

The 337th regular meeting was held on February 3, 1921 in Room 43 of the new building of the National Museum, with President WALTON in the chair and 32 members and 6 visitors present. The following were elected to membership in the society; E. H. BLACKMORE of Victoria, B. C. ; R. J. TILYARD of New Zealand; B. A. PORTER of the Bureau of Entomology; and MELVILLE H. HATCH of Ann Arbor, Michigan.

Program

R. C. SHANNON: *Notes on the classification of the Syrphidae.*

This classification is based on external characters of the adults. Ten subfamilies are recognized and practically all the characters used to define them are here used for the first time. The most notable feature in the paper is the definite separation of the *Syrphinae*, containing the aphidophagus forms, from the other subfamilies.

Dr. J. M. ALDRICH expressed himself as much gratified with Mr. SHANNON'S work on the *Syrphidae*. He stated that previous classifications of the family have been based on what might be called traditional characters which give an unnatural grouping of the genera.

L. O. HOWARD: *Extracts from Ferton's review of Fabre's work.*

Doctor HOWARD stated that he had recently carefully translated two articles from the French relating to J. H. FABRE. The first, which was an enthusiastic eulogy, was published by BOUVIER in the *Revue generale des Sciences pure et appliquees*, 26^{e} Anneé, **22**: 634–639. Paris: 30 Nov., 1915; and the second was a critical estimate of the character and work of FABRE by CH. FERTON published in *Revue Scientifique*, 16–23, September. 1916—leading article. Doctor HOWARD read abstracts from the latter article in order to show the members of the society the true estimate of FABRE that is held among the best scientific men of France, especially those best fitted by their work to appreciate at their true worth the reported observations of the Hermit Naturalist.

The translations will be bound and placed in the library of the Bureau of Entomology at the end of the series of the published works of FABRE.

Mr. S. A. ROHWER expressed the opinion that from the point of actual observations FABRE'S work does not equal that of the PECKHAMS or the RAUS. He questioned if the good that FABRE did as a popularizer of entomology would outweigh the harm that he did to the science by his bitter antagonism to the evolutionary theory. The erroneous determinations of species made by FABRE have made his work much less valuable than it would have been had he secured correct determinations from competent authorities. Mr. ROHWER stated that the same criticism applies to some extent to some American works on the habits of wasps, notably that of HARTMAN in Texas.

Mr. SNODGRASS was inclined to overlook the inaccuracies of FABRE'S work stating that in American entomological literature there are many errors as bad as those of FABRE'S. He cited as an example the statement that the tussock moth removed the hairs from its back by means of its mandibles and weaves them into its cocoon. He had observed the method by which these hairs are removed and found it to be accomplished by a revolving motion of the larva in its cocoon, by which the hairs are rubbed off and becoming tangled in the silk of cocoon form a part of the cocoon.

E. D. BALL: *Food plants and adaptations of leaf hoppers.*

Treehoppers exhibit many lines of adaptation to their surroundings. They have been chiefly famous in the past for their remarkable and bizarre shapes. These curious and intricate modifications are all the result of an extraordinary enlargement of the chitonous covering of the pronotum. These horns, spines, balls, warts, or foliaceous prolongations may be clipped off as one trims the finger nails without in any way injuring the insect whose body is of normal shape and proportion down at the base of this hood. One South American species at least appears to be able to shed without difficulty a foliaceous bulb that covers its back. This is probably a protection against insec-

tivorous birds. Most of the other strange developments seem to be protected by simulating some part of the plant on which they live or else so arranged as to blend into the lights and shadows of their favorite situation as to render them inconspicuous. For example, a species that lives on the oak has a white stripe down the middle of the back which is very striking when seen in a collection. This insect, however, in life rests on the underside of a twig in the shadows and this white stripe then functions like the light under part of the deer or of many birds and helps it to blend with its surroundings.

The adaptation of these insects to their surroundings in color and markings is if anything even more striking than their grotesque shapes. A study of the North American species of *Telamonini* shows that nearly every one of them has a single food plant to which it is almost perfectly adapted in color and form, these adaptations being combined to produce invisibility in the favorite situation of the individual treehopper. The one occurring on wild plum, for example, has the color of the plum bark and a long projection like a plum thorn. The one on sycamore has the powdery yellow appearance of the fresh bark of that tree. The one on hackberry rests in crevices in the bark and mimics the rough outline of the black and gray flecking of the rough bark.

Collecting these insects is as fascinating as trout fishing. It is only the trained eye that can detect them and when detected it is only by the use of the greatest skill that they can be captured, as once disturbed they snap into the air with eye-defying speed and are lost in the foliage. If one uses a long glass tube and brings it down from directly above the insect without allowing the slightest lateral movement they may be readily captured. They are lovers of the open and of warm and sunshiny places and will be found on isolated trees or small clumps or on the margins of woods but not inside the wooded area or in the deep shade. Fortunately for the collector most of them occur on the low spreading branches of the large trees.

Notes and exhibition of specimens

Mr. B. A. PORTER reported the rearing at Wallingford, Connecticut, of *Anaphoidea conotracheli* Girault, a common parasite of the plum curculio, from the eggs of the apple maggot. As high as 25 and 30 per cent of the apple maggot eggs collected in the field have been found to be parasitized by this insect. The egg turns dark just before the emergence of the parasite, which instead of using the oviposition puncture made in the fruit by the fly makes a hole of its own through the skin of the apple. The life cycle of the parasite was not definitely determined but data available show it to be less than three weeks. In the plum curculio it is 10–11 days. The oviposition season of the apple maggot following that of the plum curculio gives a favorable host rotation from June to September. The only other recorded host of this parasite is the grape curculio.

Dr. HOWARD was much interested in the observation and expressed the opinion that any delicate egg deposited in the same position as those of the curculio and the maggot would serve as host for the *Anaphoidea*.

Mr. GAHAN mentioned *Trichogramma minuta* Riley as another example of a parasite attacking eggs of insects of different orders.

Dr. J. M. ALDRICH, editor of the THOMAS SAY Foundation, stated that the Foundation would shortly be able to publish another memoir and asked for the opportunity to examine any manuscripts that might be available.

R. A. CUSHMAN, *Recording Secretary.*

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PHYSICS.—*Note on a general method for determining properties of matter.*[1] MAYO D. HERSEY, Massachusetts Institute of Technology.

Physical properties of substances, for example, thermal and electrical conductivity, density, viscosity, and surface tension, are usually determined by one or the other of the two following methods. (1) Absolute measurement, involving comparatively expensive apparatus and detailed mathematical analysis. (2) Relative measurement in terms of the properties of a standard sample. This method is comparatively simple and economical, but has almost always been restricted in the past to those few phenomena where the desired property is directly proportional to the observed action, or to some definite function of the observed action which can be written down in advance of the experiment. It is the object of the present paper to indicate a third category of experiments which should be available for determining properties of matter, much less restricted in character than those mentioned above; and to formulate a general method for interpreting the observations.

This third group of phenomena are characterized by the fact that the observed action will not be directly proportional to the property in question, nor even uniquely determined by it, and it is quite immaterial if the details of the phenomenon are too irregular to be analyzed mathematically. The proposed method for interpreting such observations consists merely in applying the principle of dynamical similarity (or physical similarity) backwards. Instead of employing this principle to predict the course of a phenomenon, when the properties of matter involved are altered in a known manner, it is now proposed to turn it around, and deduce the relative magnitudes of the properties of matter involved in two successive experiments, by observing the phenomena in both cases.

This possibility must immediately suggest itself to anyone familiar with the principle of similarity or the theory of dimensions, and it

[1] Received January 24, 1922.

was in fact first brought to the writer's attention through a specific instance discussed by Dr. E. Buckingham[2] at the Philosophical Society of Washington in 1916 in connection with the subject of efflux viscosimeters.

When attempting to reverse the principle of dynamical similarity, it is in general impossible to predetermine the necessary conditions because the resulting forces or motions cannot be experimentally controlled or foreseen. It is an essential feature of the proposed demonstration to show that this can be done by securing fictitious similarity by graphical interpolation among two or more experimental trials which approximate, but do not exactly realize, the conditions for similarity. Before treating the problem symbolically, this feature will be illustrated by concrete examples.

Viscosity measurement.—The familiar equation for fluid resistance due to Lord Rayleigh may be written

$$R = \rho D^2 v^2 \, f\left(\frac{Dv\rho}{\mu}\right) \tag{1}$$

in which R denotes the resistant force, D some linear dimension of the body, and v its relative speed through the medium of density ρ and viscosity μ. The function f is the same for all geometrically similar bodies. This equation can be solved for the unknown viscosity μ and written

$$\mu = Dv\rho \, \psi\left(\frac{R}{\rho D^2 v^2}\right) \tag{2}$$

or, when D and ρ are constant,

$$\mu = v \, \phi\left(\frac{R}{v^2}\right) \tag{3}$$

Now, if the functions ψ or ϕ were known, either of these equations could be used as it stands for the determination of absolute viscosity from observations on the resistance and speed. But for the purpose of relative determinations, the form of the function need not be known, as will presently appear. For suppose that the apparatus, when supplied with a standard sample of viscosity μ_o, gives an observed resistance R_o at the speed v_o, while the sample under test gives some different resistance R at a speed v; then if

$$\frac{R}{v^2} = \frac{R_o}{{v_o}^2} \tag{4}$$

[2] THIS JOURNAL 6: 154–155. 1916.

the unknown function ϕ will be numerically the same in the two experiments, so that Equation 3 gives

$$\frac{\mu}{\mu_o} = \frac{v}{v_o} \tag{5}$$

If the condition for dynamical similarity expressed by Equation 4 above could be realized at the first trial, then a single experiment on the test sample would be sufficient. In practice two or more experiments should be made and the observed values of R plotted as ordinate against v^2 as abscissa. Draw a straight line from the origin through the point whose coördinates are R_o and $v_o{}^2$. Suppose this line intersects the empirical curve for the test sample in some point P. Then the condition for dynamical similarity (Eq. 4) is exactly realized at the point P, although this is a fictitious point and not a real observation. Therefore, the abscissa v_1 of the point P satisfies Equation 5 and is to be substituted for v in that equation when using it as a working formula.

If the size of the body which is towed through a fluid, or the density of the fluid, are not constant, Equation 2 can be employed instead of Equation 3, and for this purpose Equation 2 may be rewritten

$$\mu = x\,\psi(y) \tag{6}$$

in which x denotes $Dv\rho$ while y stands for the dimensionless variable $R/\rho\ D^2v^2$. Using subscript zero hereafter to refer to the standard substance, Equation 6 gives for the standard viscosity

$$\mu_o = x_o\psi(y_o) \tag{7}$$

Now plot experimental values of y/y_o as ordinate, against x/x_o as abscissa, and call x_1/x_o the abscissa of the point where the empirical curve crosses the horizontal straight line $y/y_o = 1$. Dividing (6) by (7) the final formula becomes

$$\frac{\mu}{\mu_o} = \frac{x_1}{x_o} \tag{8}$$

of which (5) above may be considered a special case.

Thermal conductivity.—Let it be required to determine relative thermal conductivity λ/λ_o by successive observations of the temperature rise Δ on the sample under test and on a standard sample which is geometrically similar to it. When the steady state has been reached, the heat input H will be just equal to the heat carried off from the exterior of the sample by the convective action of some cooling agent such as a vigorously stirred water bath. If the specific heat of this

medium is denoted by S and its rate of flow in mass units per unit of time by M, then the temperature elevation will be given by an equation of the type

$$\Delta = F(\lambda, H, D, M, S) \tag{9}$$

in which D denotes some linear dimension of the sample. (This equation is only approximately complete; while serving well enough as it stands for the purpose of illustration, it can in practice be made more exact by introducing the additional variables ρ, μ and λ' to denote, respectively, the density, viscosity, and thermal conductivity of the cooling agent, which will have some influence on the rate of heat transfer, though not so much as the quantities M and S.) Equation 9 can be further developed by dimensional theory, and then solved for the conductivity λ, whereupon it goes over into the form

$$\lambda = \frac{H}{D\,\Delta}\,\phi\left(\frac{MS\,\Delta}{H}\right) \equiv x\phi(y). \tag{10}$$

In the second part of this equation x has been written for $H/D\,\Delta$ and y for $MS\,\Delta/H$. Plot observed values of y/y_0 as ordinate against x/x_0 as abscissa, and denote by x_1/x_0 the abscissa of the point where similarity occurs; that is, the point where the empirical curve crosses the line $y/y_0 = 1$. Referring therefore to Equation 10, the relative conductivity will evidently be given by the formula

$$\frac{\lambda}{\lambda_0} = \frac{x_1}{x_0} \tag{11}$$

In the more exact solution suggested above, the consideration of ρ will introduce an additional argument ρ^2HD^4/M^3 into Equation 10, while the recognition of μ will add an argument of the form $\mu D/M$, and so on if additional correction terms are included. In order to apply the routine reasoning above, which was based on Equation 10, these new arguments must now be held constant, which may or may not be experimentally practicable, although possible in principle if suitable facilities are provided. For example, to keep the argument ρ^2HD^4/M^3 constant, it is sufficient to increase the mass flow in proportion to the cube root of the heat input, whenever the latter is changed.

General formulation.—The procedure illustrated above may be outlined in more general terms as follows:

1. Develop the appropriate dimensionless equation for some chosen

phenomenon which exhibits the desired property of matter Q. This can be done by the Π-theorem method[3] and requires first of all a complete list of the physical quantities which would influence the phenomenon if they were to vary. Solve this equation for Q and let the result be written

$$Q = X\,\Psi(Y, Z, ..) \tag{12}$$

in which Q/X, Y, Z, ...are dimensionless variables, Ψ being an unknown function.

2. The experimental facilities must now be so arranged that all dimensionless variables other than Q/X and Y, for example Z (if any such appear), shall be kept constant. Under these conditions (12) reduces to

$$Q = X\,\psi(Y). \tag{13}$$

3. If any of the individual physical quantities entering the dimensional factor X or the dimensionless argument Y are known to be constant during the experiment, they can be left out, so that X and Y degenerate respectively into the dimensional factors x and y, and (13) takes on the more simple form

$$Q = x\,\phi(y). \tag{14}$$

Equation 14 could have been deduced at the start in place of (12) by utilizing Buckingham's recent method of suppressed dimensions.[4]

4. Take observations of the phenomenon in question when the apparatus is supplied with a standard sample, for which Q (whether numerically known or not) may be written Q_o. Denote the values of x and y which prevail during this experiment by x_o and y_o, respectively.

5. Proceed next to observe the same phenomenon with the new sample, for which Q is constant but unknown. It will be sufficient to confine the experimental variation of x to that vicinity for which the resulting value of y is found by trial to be of the same order of magnitude as y_o.

6. Plot the observed data on coördinate paper with y/y_o as ordinate against x/x_o as abscissa. Let the abscissa of point P where the experimental curve crosses the line $y/y_o = 1$, be denoted by x_1/x_o. This point represents a fictitious case of dynamical (or physical) similarity,

[3] E. BUCKINGHAM, THIS JOURNAL 4: 347–353. 1914. Phys. Rev. 4: 345–376. 1914. Trans. Am. Soc. Mech. Eng. 37: 263–296. 1915.

[4] E. BUCKINGHAM. *Notes on the method of dimensions.* Phil. Mag. 42: 696–719, § 11. 1921.

obtained by interpolation[5] between adjacent points at which the conditions for similarity were not exactly fulfilled. All of the inferences appropriate to physically similar systems are immediately applicable to the coördinates of the point P.

7. In particular, when $y/y_o = 1$, Equation 14 leads at once to the final working formula

$$\frac{Q}{Q_o} = \frac{x_1}{x_o} \qquad (15)$$

for determining the relative value of any property of matter Q. This formula is theoretically exact under the conditions stated, regardless of the complexity of the fluid motions, heat transfer, or electrical distributions involved in any given experiment.

GEOLOGY.—*The major tectonic features of the Dutch East Indies.*[1]
H. A. BROUWER, Delft, Holland.

CONTENTS

INTRODUCTION

Although the geology of parts of the East Indian Archipelago was studied in detail during the past century by several geologists, a great many of the islands, particularly those in the eastern part of the Archipelago remained almost unknown geologically. But within the last twenty years so much new information has been obtained by expeditions to the more eastern islands that it is now possible to summarize the tectonic features of the entire region—one of unusual interest to geologists and geophysicists. Here two great lines of crustal weakness, the Alpine and the circum-Pacific orogenic systems, meet or are interlaced. Although it is convenient to speak of two stages of deformation in the East Indies, it is our opinion that the latest

[5] Instead of interpolating graphically, cases might arise where it would be of advantage to employ the relation connecting derivatives; cf. THIS JOURNAL 6: 620–629. 1916; or Bur. Stds. Sci. Paper 331. 1920.

[1] Address delivered before Geological Society of Washington. Feb. 2, 1922.

crustal movements in the East Indian region are only a younger stage and a direct continuation of the Tertiary crustal movements. The Tertiary folds and overthrusts which were formed at relatively great depth are now visible at the surface, but the fissured and faulted crust that once lay above them has been removed by erosion. On the other hand, the tectonic features due to late deformation near the earth's surface during the younger stage of mountain-building have remained visible and are manifested in the fissured and faulted crust, while the accompanying folds and overthrusts remain invisible at greater depths. Thus, we believe that the displacements, evidence of which is now seen at the surface, are in part the result of the continuation of movement at greater depths and that the visible traces of the different stages of crustal movement since Tertiary time are mutually complementary. A comparison of these stages affords a better understanding of the mountain-building process.

The evolution of the region during Paleozoic and Mesozoic time is not well known, but the widespread occurrence of Mesozoic deposits, which resemble in nearly every lithologic respect the recent deep-sea oozes, proves that already in Mesozoic time deep-sea basins were present in the region. Thus certain red clay shales with radiolaria and radiolarian hornstones are the lithologic equivalents of the Recent red clay and radiolarian ooze formed in deep seas of the present day. The hornstones in places contain nodules of manganese, some of which have a concentric structure, and teeth of sharks have been discovered in places. These deposits prove that very important movements of the earth's crust must have taken place since Mesozoic time; movements sufficiently great to bring deposits formed at depths of 5,000 meters or more to heights of more than 1,000 meters above the surface of the sea.

It is permissible to conclude that the process of mountain-building in the East Indian Archipelago bears much resemblance to that of other Alpine mountain ranges, such as the Himalayas and the Alps. In the Mediterranean region of Europe it has been possible to reconstruct theoretically different Mesozoic geanticlines and geosynclines, with the aid of stratigraphic data, when it was once realized that great over-thrust sheets had been pushed forward long distances from their original sites. The study of the Recent crustal movements in the rows of islands of eastern Asia and Oceania suggests what may have been the embryonic stage of Alpine mountain ranges when (in earlier periods) a somewhat similar distribution of land and water prevailed.[2]

[2] E. ARGAND. *Sur l'arc des Alpes occidentales.* Eclog. Geol. Helv. 14:145. 1916.

In the Western Alps we find that the formation of the geosynclines and geanticlines was accentuated in the Lower Jura; in Middle Jurassic time these folds disappear below sea level; and in the Upper Jura there followed a further moderate submergence. In Cretaceous time, strong horizontal movements began and reached their maximum in the Tertiary period. As the overthrust sheets moved at greater depth, the sea-basins became narrower and the masses of the geanticlines were pushed forward in a nearly horizontal direction.

Oscillations, such as these in the Alps during the Mesozoic period are also known to characterize the younger movements in the East Indian Archipelago, and it is possible that the region adjoining the present Australian continent will in the future reach the same stage as that reached long ago in the Alps. Horizontal movements of the curving rows of islands are proved by several features now observable on those islands and as these movements proceed the sea-basins will be narrowed and eventually the masses of the present geanticlines may be pushed over the Sahul shelf of the Australian continent. Viewed thus the Archipelago may be conceived as representing an embryonic stage of an Alpine mountain range. In zoology many of the results obtained through a study of comparative anatomy were later confirmed by the results derived from studies of embryology. The development of geology, however, naturally followed lines other than those of zoology because the embryonic mountain ranges lay outside the regions studied by early geologists, but it was possible deductively to reach conclusions regarding the embryonic conditions of a mountain range by studying the anatomy of a mountain range and by applying the ontological method, a method which much more than the comparative one, has controlled geological work.

It is probable that the embryonic stages of different mountain ranges bear much resemblance to each other, as do the early stages of animal ontogeny. Such a conception leads to the recognition of unexpected relationships between types, which because of mature age show important differences. The question arises, whether persistent embryonic types occur among the mountain ranges. In the Timor row of islands deep sea-basins occurred in Triassic time, while they appear in the embryonic Alps in the Upper Jura. It is possible that in the southeastern part of the Malay Archipelago a more or less embryonic stage has persisted since Mesozoic times, while the Alps reached the mature stage in Tertiary time. In my opinion the solution of many tectonic problems will be found by a careful study of compara-

tive tectonics, embryotectonics, and comparative embryotectonics, as in zoology comparative anatomy and ontogeny are essential parts of morphology.

The tectonic features of the East Indian Archipelago as they now exist are the result of orogenic forces which have been acting during long periods of time and which have caused movements in a horizontal direction at many places. Where the lands were high above the strand-lines of the surrounding seas, the ranges were cut down and the deeper parts were uncovered by erosion; *where at the same time the crust was moving below sea-level no denudation took place* and no unconformities or disconformities in the succession of strata are found. In the parts of the earth's crust, which are now visible on the different islands the erosion intervals are not found at the same place in the geological time-table. In Sumatra a striking unconformity is found between the late Mesozoic and the early Tertiary, in Timor between the middle Tertiary and the Plio-Pleistocene. In order to give a detailed account of the tectonic features it would be necessary to describe the many islands separately but for the major tectonic features it is sufficient to describe the visible traces of two stages of crustal movements, the late Mesozoic and Tertiary stage and the youngest stage, which still continues. *The youngest stage is definitely known to be limited to certain parts of the present Archipelago*, while the distribution in time and place of the older stage is not exactly known.

THE OLDER TREND LINES STUDIED IN PLAN

Digitate forms, such as those represented by the islands Celebes and Halmaheira have been considered as produced by a broad *side- and end-on* conflict of Tertiary folded ranges. See Fig. 1. Yet it can be shown that the present morphology is the result of the youngest stage of crustal movements, since the known strike of the Tertiary folds is in places very different from the direction of the present geanticlines. In the eastern peninsula of Celebes a northwest-southeast or north northwest-south-southeast strike is found in strongly folded marls and limestones with associated layers and nodules of hornstone. In the eastern part of this peninsula the central range consists of nearly horizontal limestones of Eocene and Oligocene age. On the northern and southern slopes more or less pronounced dips to the northwest have been found. In the central part of the island the main Tertiary strike seems to be northwest-southeast. The tectonic features of the southeastern peninsula of Celebes are but little known, its northern part

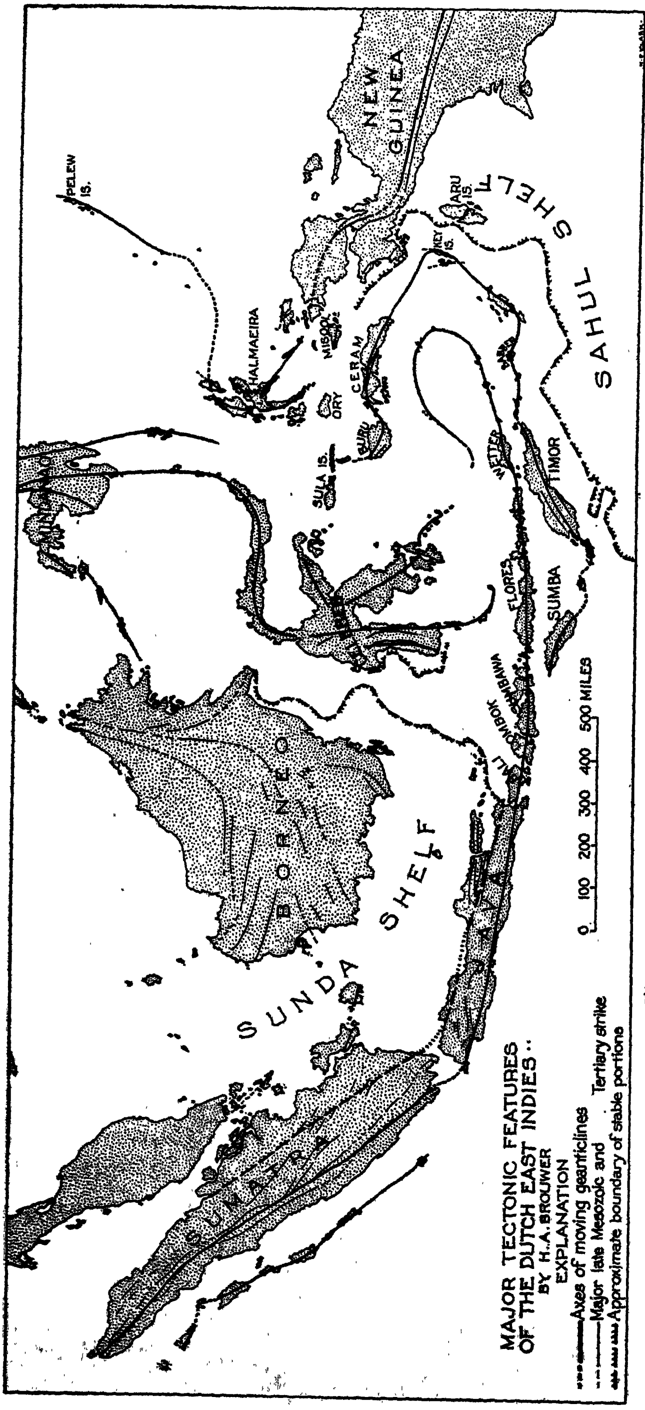

Fig. 1. Major tectonic features of the Dutch East Indies

consists principally of basic eruptive rocks and in the southern part crystalline schists, whose main strike is insufficiently known, are of widespread occurrence. In the narrow portion of the island, which connects the northern peninsula with the central part, some authors have presumed that there exists a main strike from south to north, which would bend to an east-westerly direction in the northern peninsula. But the region consists principally of crystalline schists and eruptive rocks and no folded Tertiary rocks are known, while a northwest-southeast strike seems to prevail. It is possible that the prolongation of the parallel ranges in the adjacent projecting part of Borneo crosses this part of Celebes obliquely and that the supposed bending of the Tertiary strike does not exist. Thus viewed, the Tertiary mountain-plan of the island may be thought of as comprising two strongly diverging trend lines of which the northern recurves to the north in the direction of one of the trend lines of the Philippine islands. To repeat, particularly in that part of the Archipelago which is occupied by the Island of Celebes there are *important differences between the Tertiary strike and the direction of the present geanticlinal axes.*

The geologic plan of Borneo in many respects resembles that of Celebes in that it is not well explained by a "side and end-on" conflict of folded ranges, but on the contrary suggests the existence of a system of branching trend lines similar to that of the present Philippine islands. From the northeastern part, where the highest elevations of the island occur and where the folded ranges with a main trend north-northeast to south-southwest are closely crowded together, the main strikes diverge to the southwest. The eastern trend lines bend to the southwest in the direction of Celebes, those more to the west first have a direction from north to south, but bend to the southwest, while the central and western ranges recurve to the northwest, almost at right angles to their general course in the northeastern part of the island.

The plan of Sumatra is similar to that of Borneo, although the branching of the trend lines is not so distinctly pronounced. The highest altitudes of the older rocks occur in the northwestern part of the island and the main trend lines diverge to the southeast.

The reconstruction of the main older trend lines in the eastern part of the Archipelago cannot be made complete, because that part of the region is mostly covered by the sea and older folds in many places are cut off by the present coast lines. There are, however, some indications that virgations also occur here. In the islands of the Kei

group a NNE-SSW strike is found on Great Kei, while farther west a NNW-SSE strike in the direction of Ceram has been observed. The strike on Great Kei is in the direction of western New Guinea, where the strike is parallel to the coast line (NNW and NW).

As far as known the main strike in different parts of Halmaheira Island does not greatly differ from the longer axes of the present peninsulas. But as the island has been crossed at only a few places and as eruptive rocks are of widespread occurrence, positive opinions on the tectonic relations are not warranted.

THE OLDER OVERTHRUSTS STUDIED IN PROFILE

The great deformation that took place during late Mesozoic and Tertiary time, and now so well exhibited on many of the islands was caused by strong pressure exerted from several different directions and the structures that were developed show the imbrication and the different degrees of overthrusting characteristic of Alpine mountain ranges. This structural type is probably of widespread occurrence, since it has already been proved or rendered highly probable that it is present on Sumatra and on many islands of the Timor-Ceram range. It has been suggested that the highest and the lower eastern parts of the Barissan mountains in Djambi (Sumatra) are parts of an overthrust sheet, between which the autochthonous phyllitic slates have been uncovered by erosion. An erosion relict has been found in the Bukit Raja.

In the Highlands of Padang the walls of Carboniferous or Permian limestone in places continue uninterruptedly without any transgression-conglomerates and without veins of granite or contact phenomena over the contact between granites and surrounding sediments, whereas part of the granites is post-Carboniferous in age. These limestones give to the landscape a peculiar character similar to that of the "Klippen" of the Alps and the Carpathian mountains and the "fatus"[3] of Timor.

On Timor the majority of the isolated rock peaks consist of coral reefs of Upper Triassic age, but Permian crinoidal and fusulina lime stones are common. Groups of deposits of the same age, but of different paleontological, and petrographical character, occur one on top of the other and "fatus" of older rocks are found resting on younger oceanic deposits, as is clearly visible along the deep ravines cut in the recently elevated island. The structure is as a rule chaotic and is similar to that of the higher overthrust sheets of eastern Switzerland,

[3] Isolated rocks or groups of rocks in Timor are called "fatu" by the natives.

which were moved in the near-surface zone where the rocks yielded to pressure not by flow but mostly by fracture. The comparative method of study leads to the supposition that on Timor the deeper complicated, but less chaotic overthrust structures, such as are found in the Western Alps, have not here been uncovered by erosion, and the absence of rocks older than those of Permian age points to the same conclusion. Simpler structures are found only in the southern coast-range of the island, where an imbricated structure with a fairly uniform dip to the north-northwest prevails. On Babber, an island to the east of Timor, crinoidal limestone has been found as isolated "fatus," which rest on folded Jurassic sediments. In the eastern part of Ceram Triassic sediments are thrust over limestones and marls, which are partly of late Mesozoic age and which show a rather regular dip to the southwest. In the central and western part of the island several remarkable successions of crystalline schists, phyllitic slates, and Mesozoic rocks point to the existence of important overthrusts between these three formations. In the western part of the island the horizontal movement of the overthrust seems to be less than that on the southern islands of the Timor-Ceram row, because groups of deposits of the same age, but of different paleontological and petrographical character, are not found one on top of the other and in close proximity in the same degrees as on Timor.

The expeditions from the south coast to the Snow Mountains of the central range of New Guinea found strata with a fairly uniform dip to the north over long distances and it does not seem improbable, that recumbent folds, imbricated structures, or overthrusts, with a movement in the direction of the Australian continent may occur in these mountains. This chain bears towards the lowland to the south and to Australia beyond a relation somewhat similar to that borne by the Himalayas towards India.

REGIONS WITH SIMPLER STRUCTURES

In Sumatra the overthrusts are older than Tertiary, in Timor they were formed in Miocene time. The Tertiary rocks of Sumatra up to the Pliocene generally have been folded, often in more or less regular broad anticlines and synclines, such as those of the oil-bearing strata in the eastern part of the island. Similar relations prevail in other regions where in Neogene time there were geosynclinal belts persistently and fairly well filled with an accumulation of sediments, as in parts of Java and Borneo and also on some islands in the eastern part of

the Archipelago. In some parts of the Archipelago the *Mesozoic and Tertiary rocks both show simpler structures.* In western New Guinea to the south of the Gulf of the Mac Cluer normally folded Tertiary rocks occur, and farther west, in the Misol-Obi-Sula row of islands in places the Jurassic strata are but slightly folded or are nearly horizontal. On Borneo crustal deformation of the late Mesozoic stage is clearly visible, but at many places the dip of the Cretaceous strata is not very pronounced. The tectonic structure may be more complicated in the northeastern part of the island, where the folded ranges are closely crowded together. Sumba, is usually considered as the western prolongation of the Timor row of islands, but the Tertiary is not distinctly folded.

On Celebes the ages of the different strata are not yet exactly known. It has been supposed that even Tertiary sediments occur amongst the metamorphic sediments, which are of widespread occurrence on the island, but as yet there is no proof of this supposition. In the central part of the island large anticlines and synclines with an approximately northwest-southeast strike were formed in post Eocene time. In the eastern peninsula nearly horizontal Eocene limestones occur, but at other places, as in the western part of the eastern peninsula, rocks of the same age are intensely folded. Although simpler structures with large anticlines and synclines certainly prevail in a large part of the island, we cannot gain an adequate picture of the late Mesozoic and Tertiary tectonic features of the whole island until the stratigraphy is more completely known.

THE MAIN TREND LINES OF THE YOUNGEST STAGE OF MOUNTAIN-BUILDING

The main trend lines of the latest stage of mountain-making are accurately known, because uplifts of the land relatively to the sea level are clearly demonstrated by the presence of elevated fringing reefs and because the positions of the deep-sea basins are given on the deep-sea chart of the "Siboga" expedition. The deep-sea basins have proved to be elongated more or less precisely parallel to the adjoining rows of islands and the main trend lines of the youngest stage of mountain-building nearly coincide with the longer axes of the islands. The deep sea basins and the strongly elevated islands are confined to the eastern part of the Archipelago, whereas within the western area there prevails a slight and uniform depth of the sea with smooth outlines of a land that rises with a gentle slope from the coast. Only the southern part of the Archipelago which is bounded by the Indian Ocean, shows

proof of recent upheaval of the land, while the deep-sea chart shows a complicated topography to the south of Java and Sumatra. That these movements still continue is proved by the distribution of earthquakes in the Archipelago. In the region including eastern Sumatra, the southern China Sea, northern Java, and Borneo, heavy tectonic earthquakes are practically absent. The shocks felt in this area have their origin in the mobile areas, which are as a rule submarine, as shown by the seismic epicenters.

The large bendings in the mountain chains of recent age in the southern and eastern parts of the Archipelago are clearly visible on the deep sea chart of the region. But if considered in detail it is obvious *that important bendings of smaller amount are numerous*. They are not always clearly visible in the present topography, because many of the bending-points, which are the loci of considerable transverse fractures, are covered by the sea. Examples of this kind are the narrow Manipa Strait between Ceram and Buru, nearly 5,000 M. deep, the strait between Timor and Rotti, the strait between Timor and the Sermata islands, and Sunda Strait between Java and Sumatra. In the row of islands from Nias to Enggano, to the west of Sumatra, several examples of this kind also occur.

TERTIARY STRIKES ARE CUT OBLIQUELY BY THE PRESENT GEANTICLINAL AXES

The establishment of the fact that Tertiary strikes are cut obliquely by the present geanticlinal axes is of great importance for a precise understanding of the mountain-building process. Several examples are known in the Dutch East Indies. On the south coast of Timor the strike of the Jurassic and Cretaceous strata of the Amanuban mountain chain differs about 12° from the general trend of the coast line. The high mountain range of central Ceram, in which the Mesozoic and Tertiary strata strike about NW-SE, is cut off abruptly at the coast with a general E-W trend. The abnormal strike in the eastern peninsula of Celebes and in the narrow portion which connects the central part of the island with the northeastern peninsula have been already mentioned. Another noteworthy example is on the island Babber to the east of Timor, where the strike is NNE-SSW, nearly perpendicular to the main trend of the present row of islands.

Similar facts are well known from Japan. Von Richthofen believed the formation of the arcs to be due to a rupture (Zerrung) caused by the subsidence of the oceanic side, and denied the existence

of the zonal structure that characterizes folded mountains of the Alpine type. Japanese geologists have already pointed out that many of the dislocations are only recurrent movements on the arcs of folding, which are of essentially the same type as the Himalayas and the Alps in their fundamental structure.

The abnormal strike can be explained in a simple manner by the action of compressional stress, if we suppose that the rows of uplifted and fragmented island blocks indicate the places where at greater depths folding continues and that there is motion in a vertical direction as well as *considerable motion in a horizontal direction*. The vertical movement will cause gradual erosion and the exposed surface of the geanticline will in time consist of rocks which were in the zone of flow during an earlier stage of mountain-building. The rate and direction of the movement of the deeper-lying rocks as they approach the earth's surface may differ more and more from the rate and direction of the motion of the rocks that lie at still greater depths on the same vertical line. The forces that cause movement near the surface will generally differ in intensity and direction from the forces that cause movement at greater depths. Furthermore, the rate of transmission of the forces will decrease from the surface to the zones of greater plasticity at greater depth. If during the elevation the rate of horizontal movement is different for neighboring parts of the geanticline, the differences between the directions of the geanticlinal axes and of the older strike may be considerable, as in the central part of Ceram. The strong bending of the geanticlinal axis between Ceram and Buru points to important differences in the rate of horizontal movement for neighboring parts of the geanticlines. A bending-point existed in this region already in Tertiary time and near strong bendings, as near Babber Island, the Tertiary strike may locally even be at right angles to the present geanticlinal axis. It is particularly in such places that the movement at or near the surface may differ considerably in rate and direction from the movement of greater depths.

THE FRACTURES DURING THE YOUNGEST STAGE OF MOUNTAIN-BUILDING

The tension hypothesis of von Richthofen has been applied by some authors to the East Indian Archipelago, but the numerous fractures, which are known to exist, are in our opinion the surface expression of vertical and horizontal movements which are the result of compressional stress. Important fractures occur near the surface at those places where there are important differences in rate of move-

ment. If the forces which cause the movement are deep-seated and if the crust near the surface does not respond to the direct influence of the compressional stress, displacements near the surface will result from the more plastic deformation at greater depth. While important horizontal movements are taking place in the zone of plastic deformation, the superficial parts may move with much less velocity.

If the superficial parts are bent, whether in a vertical or horizontal plane, there is a tendency to produce gaping fissures upon the convex side of the bend, while there is compression upon the concave side. Some of the fissures in the Archipelago may be of this origin, and many have been explained in this way, such as the basins of central Celebes, which are arranged in straight lines, more or less parallel to the geanticlinal axes If studied in plan, the same principles are applicable and perhaps some of the straits between the islands of an arc have been formed in this way. Considerable transverse fractures, however, which occur at many places near the bending-points of the geanticlinal axis, can be explained by *difference in velocity of horizontal movement* for neighboring parts of the fold along the axis. In the same way important longitudinal fissures can be explained by the difference in velocity of neighboring parts of the geanticline considered in a vertical plane at right angles to the geanticlinal axis. The morphological aspect of the surface will be controlled chiefly by the more or less horizontal movements on transverse fault planes, the gaping transverse fissures on these planes the more or less vertical movement on longitudinal faults, and the gaping longitudinal fissures on these faults. The movements along more or less horizontal fault-planes will not be of much importance for the major morphological structure and will receive no further consideration.

Typical examples of transverse fractures near the bending-points of a geanticlinal axis where it has moved forward horizontally are Sunda Strait between Java and Sumatra, the strait between Timor and Rotti, and the narrow strait between the main island of Rotti and the peninsula of Landu. To the east of Timor the small Island of Kisser which is surrounded by deep seas and is in the neighborhood of a bending point between east Timor and the Sermata Islands occupies a northern, non-harmonic position. Farther to the east the Babber group, which consists of small islands with high reefs, is separated by a considerable gap from the islands of the Tenimber group. The narrow strait between Muna and Buton and the straits between other

islands of the same group are near the bending-point of the geanticlinal axis of the Tukang Besi Islands and southeastern Celebes. The narrow Manipa Strait, nearly 5,000 meters deep between Ceram and Buru is another example of an important gap where there is strong bending of the geanticlinal axis in a horizontal plane, while the strait between Halmaheira and Morotai and the important gap between Halmaheira and the islands to the southwest of the Pelew group may in part be the result of fractures near a bending-point, which possibly exist between Halmaheira and those islands. Of course in large bendings of the geanticlinal axis the submarine parts of the axis may be due to a pitch of the axis, but for relatively short bendings this explanation of submarine portions alone is not applicable. The fracture-movement may be more or less parallel to a fault-plane or the movement may have an important component normal to the fracture-plane The bending-points of the surface of the geanticline, considered in a vertical cross section of the geanticline at right angles to the geanticlinal axis, are between the deep sea-basins and the elevated islands, where longitudinal faults may cut away the land at the coast as has been mentioned for many islands of the Archipelago. If two more or less parallel rows of islands are developing as two secondary geanticlines with an intermediate secondary geosyncline, longitudinal faults may exist on both sides of the secondary geosyncline and on the outer sides of the secondary geanticlines. The duration, speed, and place of the fracture-movements will in large measure depend upon the evolution of the mountain-building. If the plane of movement is not constant and the traces of older fracture-movements are elevated above the sea, they will usually disappear rapidly through erosion on the outer side of the geanticline. If the secondary geosyncline during its slow subsidence constantly remained fairly well filled with an accumulation of sediments and if in a later stage of evolution a general elevation of the secondary geosyncline and geanticlines takes place, the filling of the central basin will serve as evidence of older fracture-movements on both sides of the original secondary geosyncline. Different stages in this evolution are represented in the Timor-Ceram row of islands.[4] The islands of the Tenimber group consist of two rows with elevated reefs, which are separated by a zone in which during the latest stage of the mountain-building process positive movements have prevailed. At Timor the geanticline may have already passed through the stage of

[4] H. A. BROUWER. The horizontal movement of geanticlines and the fractures near their surface. Journ. of Geol. 29: 566. 1921.

development represented by Tenimber Islands. Flexures and faults of considerable horizontal magnitude occur at the walls of a central basin which has been formed and filled with sediments in Plio-Pleistocene time. Later a general elevation of the island has produced the large anticline of the present island, with the highest reefs in the central part. We suppose that in this later stage of evolution the rate of horizontal forward progression of the deeper parts was greater than that of the superficial parts and that the parts which were near the surface and originally were above the downward moving secondary geosyncline were in a following stage of evolution above rising parts at greater depth and were, therefore, elevated above the sea.

A fine example of parallel rows of islands which are developing as geanticlines with intermediate geosynclines are the Tukang Besi Islands southeast of Celebes. They consist of four rows—two of which bear elevated reefs and mark the geanticlinal axes; while the other two are characterized by reefs and atolls, and mark the geosynclinal axes.

Only a limited number of the general types of fracture-movements have been described. The position of the fissures and faults is controlled by a great many factors, the discussion of which would exceed the scope of this paper. But the types mentioned sufficiently illustrate the thesis, that the majority of the fractures in the East-Indian Archipelago are the surface expression of differences in velocity of horizontal and vertical movements, which are the result of compressional stress. That these movements still continue is proved by the position of the epicenters of modern earthquakes, of which we will mention those along the southwestern prolongation of the transverse dislocation in Sunda Strait between Java and Sumatra.

LITERATURE AND MAPS

A bibliography of the more important publications on this subject to 1917 is given in the Jaarboek van het Mijnwezen in Ned. Indie, Verhand. 1917, II, with Atlas. Our map is compiled from the maps in this atlas with additional information.

Since 1917 there have appeared other publications for which see the annual bibliography of geological publications on the Dutch East Indies by R. D. M. VERBEEK in Verhand. Geolog.—Mijnbouwk. Genootschap voor Nederland en Kolonien.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

858TH MEETING

The 858th meeting of the Philosophical Society of Washington was held in the Cosmos Club auditorium, December 17, 1921 and was called to order at 8.15 p.m. by President CRITTENDEN, with thirty-nine persons present. The program was as follows:

W. W. COBLENTZ: *The effective temperature of stars as estimated from the energy distribution in the complete spectrum* (illustrated). The paper was discussed by Messrs. PRIEST, HAWKSWORTH, FOOTE, HUMPHREYS and CRITTENDEN.

The object of the present investigation was: (1) to test new stellar thermocouples; (2) to verify previous measurements of stellar radiation; (3) to measure the radiation intensities of bright stars in the region of 0 hours to 12 hours of right ascension, not previously measured; and (4) to determine the feasibility of the method of obtaining the spectral energy distribution of stars by means of transmission screens which, either singly or in combination, are placed in front of the vacuum thermocouple.

By means of vacuum thermocouples, measurements were made on the total radiation intensities of 13 bright stars not observed in 1914, thus completing the survey of the whole sky. A total of 30 celestial objects were measured, including Venus and Mars.

By means of a series of transmission screens (of yellow and red glass, of water, and of a thick plate of quartz), wide spectral regions were isolated and the radiation intensities in the spectrum from 0.3μ to 0.43μ; 0.43μ to 0.6μ; 0.6μ to 1.4μ; 1.4μ to 4.1μ; and 4.1μ to 10μ were determined. In this manner the distribution in energy in the spectra of 16 stars was determined, thus obtaining for the first time an insight into the radiation intensities in the complete spectrum of a star.

By means of these transmission screens it was found that in the *B* and *A*-class stars, the maximum radiation intensity lies in the ultra-violet (0.3μ to 0.4μ) while in the cooler, *K* and *M*-class stars, the maximum emission lies at 0.7μ to 0.9μ, in the infra-red.

A calculation is made of the spectral component radiations of a black body at various temperatures, using the spectral transmission data on these screens. From a comparison of the observed and the calculated spectral rediation components, it appears that the black-body temperature (*i. e.*, the temperature which a black body would have to attain in order to emit a similar relative spectral energy distribution) varies from 3,000° C. for red, class *M* stars (6,000° for the yellow, solar type) to 10,000° or perhaps even higher for blue, class *B* stars.

The observing station being much higher than that previously used (7,300 feet as compared with 4,000 feet), the atmospheric scattering of light was greatly reduced; consequently, when the water cell was interposed the transmissions in the violet were somewhat higher than previously observed. However, all the data verify previous measurements showing that red stars emit 3 to 4 times as much infra-red radiation as blue stars of the same visual magnitude. Moreover, observations made on the same night (same weather conditions) are consistent in showing small gradations in the infra-red radia-

tion component that correspond with the small gradations (say B2 and B8) in spectral classes.

For binary stars having companions of low luminosity the water-cell transmissions are low, indicating that the companion stars emit considerable infra-red radiation.

Among the subsidiary investigations made with a view to the improvement of stellar radiometers, the complete paper gives data on the radiation sensitivity of thermocouples of alloys of gold-palladium, platinum-rhodium, bismuth-tin, bismuth-antimony, and also of pure bismuth.

In conclusion, it is relevant to note that in comparison with the photo-electric cell the thermocouple is far less sensitive, and hence the number of stars that can be measured by it is more limited. Neither instrument can tell us the size or distance of stars. The thermocouple enables one to obtain information not obtainable by other instruments. Combined with an absorption cell (of water) one can detect the presence of dark companions of binary stars. This device also gives us a new means for studying planetary radiation and temperature conditions. If the surface of a planet becomes warmed by the sun's rays, and in turn emits radiation (which will be entirely of long wave-lengths) the amount of radiation transmitted through the water cell will be less than when the reflecting surface remains cool. Data of this type were previously obtained on the moon. Applied to the planet Mars, if the polar cap is snow, then the transmission of reflected sunlight should be higher than that observed from the dark areas, if the latter are bare ground. On the other hand, if the dark areas contain green vegetation (similar to that of our earth) the temperature rise will be small, the water-cell transmission will be high, and the results may be difficult of interpretation.

PAUL D. FOOTE, F. L. MOHLER and W. F. MEGGERS: "*A significant exception to the principle of selection*" (presented by Mr. Foote and illustrated). The paper was discussed by Mr. HAWKSWORTH.

The pair 1s − 3d of sodium and potassium, in Sommerfeld's theory necessitates an interorbital transition where the change in azimuthal quantum number is two units. The presence of this pair has always been attributed to the incipient Stark effect of the exciting field. In the present paper an experimental arrangement is described wherein the radiation is completely shielded from the applied field, itself only 7 volts. The pair may then be produced at will by increasing the exciting current until it is one of the strongest lines of the spectrum. It therefore is an exception to the selection principle which cannot be explained away by a Stark effect. Its explanation is of deeper origin, possibly requiring a reconsideration of the method whereby single azimuthal quantum numbers have been assigned to each of the s, p, d and b terms.

WALTER P. WHITE: *Some precision pendulums* (illustrated). The paper was discussed by Messrs. PAWLING, PRESS, TUCKERMAN and SILSBEE.

Pendulums are practically always driven by a push in the direction of motion. This may take two forms: (1) A direct push is given symmetrically about the middle of the stroke. This is usually done by force applied at right angles to the direction of motion, acting on an inclined surface (pallet). This method involves considerable friction and consequent possibility of irregularity. (2) The pendulum meets and pushes against a pallet which acts on an opposing weight or spring, and which follows the pendulum in the return to a point beyond that at which it was picked up. The opposing pallet

is then brought back to the original position by the driving train of wheels. This arrangement is equivalent to a push over the distance between the two points, those of meeting and leaving the pallet. Here friction is less, but is not completely absent, since there is friction in unlocking the train each time it moves.

If electric working is introduced friction can be entirely avoided. An impulse can be given magnetically at the middle point of the swing, but the difficulty of keeping this impulse constant and applying it at exactly the right time seems to make this method less satisfactory than an electrically-operated form of the second type of drive, which is now exceedingly simple. The pendulum merely lifts a small pallet, contact with which causes a current to flow, which by means of a magnet shifts the stop of the pallet. Contrary to some rather positive statements, it has been found by several experimenters that the contact in this form of drive can be operated without any friction and with pressures less than 1 gram.

Some very simple equations were developed for determining the magnitude of the errors with this arrangement, and hence the best practical dimensions to give it in any particular case. These equations are applicable to the other forms of drive, and show: (1) A light and long pallet is preferable as long as the pressure is sufficient for proper contact. This is because the errors due to friction, or to displacement, or wear of the stops, become less as the length increases. (2) The error from displacement of the stops, that is, from improper timing of the driving pressure, is a minimum when this pressure extends over half the swing. Contrary to much received opinion, therefore, an instantaneous impulse at the middle of the swing may be a relatively disadvantageous method of driving. (3) It is possible, and sometimes probably advantageous, with the second form of drive, to arrange to compensate for the circular error of the pendulum, that is, the error caused by variation in arc of swing. (4) In the Riefler mechanism, which belongs to the second type of drive, the driving pressure acts over an arc which is dependent on the speed with which the escapement wheel revolves when unlocked. This is really a disadvantageous element in the design, against which, however, are to be set the efficiency of the unlocking arrangement and the general good workmanship of this make of pendulum.

Adjournment at 10 p.m. was followed by a social hour.

H. H. KIMBALL, *Recording Secretary.*

BIOLOGICAL SOCIETY

627TH MEETING

The 627th meeting of the Biological Society of Washington was held in the lecture hall of the Cosmos Club, May 14, 1921, at 8.00 o'clock. President HOLLISTER was in the chair, and 28 persons were present. The minutes for the 626th meeting of April 30 were read and approved, and the following were elected to membership: DR. RUDOLPH KURAZ, MR. E. C. LEONARD and ROBERT F. GRIGGS. It was announced that the present meeting was the last before the summer recess.

Informal Communications: Dr. T. S. Palmer stated that doubt rests upon the native origin of oppossums in California. There is a record ninety years old of oppossums on the California-Mexico border. Dr. Grinnell shows, however, that oppossums were introduced in the San Jose neighborhood in

1910, and these have flourished. 200 skins have been marketed in the last two years. Dr. R. W. Shufeldt exhibited two new books, (1) Early Annals of Ornithology, by John H. Gurney, containing quotations from early literature. (2) Life of Samuel White, by his son, Capt. S. A. White. Mr. F. C. Lincoln stated that one of a hundred common tern which were banded in Eastern Rock, Maine, on July 3, 1913, was found floating upon the Nile River, Africa, in August, 1917. This record points to the possible identity, which has been questioned, of the European and American Common Tern. Dr. R. E. Coker announced a 3 day conference to be held in June at Fairport, Iowa, on conservation of life in inland waters, under the chairmanship of Dr. S. A. Forbes. Great interest and appreciation of the problems involved is already apparent. Mr. Libbey stated that during the day Bicknell's Thrush had been seen, and Rose-breasted Grosbeaks were feeding upon oak galls. Dr. T. S. Palmer stated that while Bicknell's Thrush undoubtedly passes through the District of Columbia, it had never before been seen. It was described from Colombia many years before Bicknell was born. Dr. Palmer made a minute upon the death of Mr. William Palmer, born in England in August 1856, died in New York City, April 8, 1921. He was appointed taxidermist in the National Museum at the age of 18, where much of his work exists. He was on many extended tours, and was a member of the Council of the Society at the time of his decease.

Formal Communications: F. G. ASHBROOK, *Recent notes on the fur trade in the United States.* He said in part: Prior to the World War the world's fur market was in London. St. Louis and New York now are the fur centers. The value of the raw skins ranges from 1–7 millions annually. In 1920 the finished value was $84,000,000; exports were $34,000,000. The turnout during the 1920 fur sale in 1921 will be $352,000,000 in which the taxes will be $15,000,000. Thus the growth of a once neglected industry: Fur bearing animals are little protected by general agitation among the public. It requires legislation which preserves the game without destroying the trade. Since 25% of the skins are unprime, the seasons should be properly limited and trappers licensed. Reports should be made under oath, and licenses should be denied or cancelled upon occasion. Certain regions should at times be closed, with proper protection to farmers against enemies. The laxity of enforcement of laws in some states is to be deplored. Rearing and stocking is to be encouraged; it is successful when intelligently done. There are 500 persons in the United States breeding animals for their skins.

Mr. Ashbrook's paper was discussed by Mr. Doolittle and Dr. Palmer.

MR. S. A. ROHWER: *Injurious and beneficial insect galls.* He said: A gall is a malformation in plant tissue made in course of the development of insect larvae. Galls may be due to the irritation of oviposition or to some enzyme or both. In either case the insect has abundant nourishment. The galls made by different insects are characteristic. Galls have furnished topics for poems and other literature. Their use in medicine is based largely upon superstition, but they are a source of astringents.

As related to man some galls are slightly or not at all injurious to plants in which he is interested. Such are the Cynipid galls on oak leaves, and many others on roots and twigs. The beneficial aspect of galls is recent. They are the basis of some dyes, and all permanent black inks of United States and Europe. The superiority of London seal skins over Paris skins was due to the Aleppo gall from Turkey. A Chinese gall produced by aphids on *Rhus*

is a fair substitute for the Turkey product. One firm uses $150,000 worth in one year. The California Oak Apple is large, contains 30% tannic acid, and makes satisfactory ink. The Texas Ball also has high content.

There are two types of tannin, the iron-green and the iron-green-blue. The chemistry of galls still requires investigation, as not all galls produce tannin of equal value.

Some galls are injurious. In 1917 galls destroyed in a large area all the acorn catkins, destroying the acorns and the hog forage in that region. Other galls kill growing tissues, causing a second growth. An internal gall occurs in California. No damage is observable until the insect emerges and no defensive measures are possible.

The paper was illustrated by lantern slides of various galls and gall insects, and tables showing the tannin content of many fresh and cured galls. Mr. E. A. Goldman discussed the paper.

The Society adjourned at 9.55.

A. A. DOOLITTLE, *Recording Secretary.*

628TH MEETING

The 628th meeting of the Biological Society of Washington was held in the Lecture Hall of the Cosmos Club, October 29th, 1921, with Vice President GIDLEY presiding, and 36 persons present. The minutes of the 627th meeting of May 14th were read and approved, and Messrs. FRANK E. ASHBROOK and J. WADE were elected to membership, and Mrs. JULIUS PARMALEE and Miss ERMA BROWN.

Informal Communications: Dr. T. S. Palmer announced the annual meeting of the American Ornithological Union at Philadelphia on the 8th, 9th and 10th of November. Dr. H. M. Smith gave some records of the Kamchatka Sea Eagle. The bird had been seen at Urangel in 1905, at Unalaska in1906 by Austin Clark and by Professor J. V. Snyder, seen also in Juneau in 1909. Specimens have been taken by Dr. Hansen at the Pribloff Islands, and again a specimen was taken at Kodiak Lake August 10 of this year. This is not a marine bird, but rather of forests and rivers.

Formal Communications: DR. R. S. BASSLER: *Sex characters in fossils.* The speaker said that sex is recorded plainly in vertebrate skeletons, and thus easily recognized in fossils, but a similar condition does not occur generally among invertebrates. However among Bryozoa and Ostracoda found as fossils sex organs are present.

Recent Ostracods are without external sex structures, but paleo-species have little swellings which careful study proves to be brood pouches, thus distinguishing the sexes. The form, size and arrangement of these pouches assist in their classification. Silurian and Paleozoic species are found with these pouches, earlier and later species are without them.

The general structure of Bryozoa was described and the relation of the brood pouch or ovisac to the rest of the anatomy was shown. The transition from a very simple type to a more complicated type was traced, and the taxonomic value of this character was shown. It is only in the form or position of the brood pouches or ovisacs that distinction between many species is found. Many species formerly regarded as identical are now differentiated. All previous classification has thus been rendered obsolete; only those species are classified in which the distinctive character appears as shown in the ovicell.

The paper was illustrated by numerous lantern slides and was discussed by Messrs. Gidley, Rohwer, Oberholser and Doolittle.

DR. W. E. SAFFORD: *The Dahlia, its origin and development.* Dr. Safford stated that the botanical relationships of the cultivated Dahlia are difficult to trace, having been crossed and recrossed under cultivation before they were known to Europeans. They were first described and figured in 1791, from specimens of Mexican origin by Cavanilles. Descriptions of some Dahlias antedate the technical descriptions some 200 years in a study of the resources of New Spain. At that time Hernandez describes varieties in form and color showing that types thought to be modern were already developed. Many of the interesting and remarkable modern forms have been developed by crossing with a distinct type, *Dahlia juarezii.* Wild species have been found in the mountains of Mexico and Central America by Maxon and Popenoe which bear their discoverers' names.

The roots of the Dahlia are clustered and fleshy, containing not starch but inulin, from which levulose or fructose is obtained. Owing to a bitter flavor the roots are rejected by cattle and pigs. The levulose, however, is 60% sweeter than sugar, and, since it crystallizes with difficulty, has great possibilities as a syrup in sweetening drinks and desserts and preserves.

Dr. Safford's paper was illustrated with many beautiful colored slides of the various types of Dahlias, including reproductions of the earliest drawings. The paper will appear in another connection in the Journal of the Washington Academy of Sciences. The paper was discussed by Messrs. Rohwer, Oberholser and others.

The Society adjourned at 10.00.

A. A. DOOLITTLE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The Executive Committee of the Institute for Research in Tropical America held its first meeting Saturday, January 14, at the rooms of the National Research Council, for the purpose of organizing. A. S. HITCHCOCK, representing the Smithsonian Institution, was elected Chairman; H. E. CRAMPTON, of the American Museum of Natural History, Vice-Chairman; and A. G. RUTHVEN, University of Michigan, Secretary-Treasurer. The Institute now includes 19 members.

Arrangements have been completed for enlarging the scope of the *Journal of the Optical Society of America.* Beginning January, 1922, the publication will be known as the *Journal of the Optical Society of America and Review of Scientific Instruments.* In addition to the papers on all branches of optics heretofore carried, about three eighths of the total space will be devoted to instruments other than optical. Beginning with May, 1922, the Journal will be issued monthly instead of bi-monthly. The new Journal has been placed on a strong financial basis and has the support of the Optical Society, of the Association of Scientific Apparatus Makers of the United States of America, of the National Research Council, and of several philanthropic individuals interested in making the plan a success. Authors will welcome this new feature as it affords almost the only source for the publication in this country of papers describing instruments. DR. PAUL D. FOOTE of the Bureau of Standards is editor-in-chief and DR. F. K. RICHTMYER, Cornell University, is assistant editor-in-chief and business manager.

Among recent accessions by the Division of Plants are the following:

692 specimens of West Indian plants, chiefly from Trinidad, received as an exchange from the New York Botanical Garden; 836 specimens from Brazil, collected many years ago by GARDNER and containing a large number of duplicates of types, received as an exchange from the British Museum; 593 Panama ferns presented by MRS. L. R. CORNMAN, San Diego, California; 400 specimens from the French Congo, received as an exchange from the Jardin Botanique de l'Etat, Brussels; 277 African grasses collected by DR. H. L. SHANTZ, received as a transfer from the Bureau of Plant Industry, U. S. Department of Agriculture; 300 Panama plants presented by Brother HERIBERTO, Panama City; 167 Cuban ferns, received as an exchange from the New York Botanical Garden, and 126 Philippine orchids, largely cotypes, received as an exchange from MR. OAKES AMES, Boston, Massachusetts.

A series of specimens showing the complete working of the "Manul" process of reprinting sent by the Polygraphic Company of Laupen-Berne, Switzerland, is on exhibition in the Division of Graphic Arts, Smithsonian Institution. This process eliminates all resetting of type or the use of a camera. The page is placed in contact with a sensitized transparent film and exposed to the light. The light reflecting from the white parts of the original affects the sensitized film while no reflection of light from the blacks leaves the film unaltered. This film is used as a negative after being treated with coloring matter and transfers the image to the zinc or aluminum plate which is printed on a lithographic press in the customary manner.

In this process any work, written, drawn or printed, can be reproduced at an obvious saving over older methods involving resetting all type matter or making photographic negatives by the use of a lens and camera. The exhibit includes the original pamphlet, the "Manul" film, the zinc lithographic plate and a finished print.

Dr. C. G. ABBOT, Assistant Secretary of the Smithsonian Institution, returned to Washington January 4 from a trip of inspection to the Institution's solar radiation station at Montezuma, near Calama, Chile.

Captain ROALD AMUNDSEN, the well-known polar explorer, visited the Department of Terrestrial Magnetism of the Carnegie Institution of Washington on January 16, in order to complete arrangements with regard to coöperative work in terrestrial magnetism and atmospheric electricity between the Department and his forthcoming expedition to the Arctic Regions. During the Northeast Passage, 1918–1921, the Amundsen Expedition made a series of highly valuable magnetic observations at somewhat over 50 different points. Captain Amundsen's chief scientific assistant, Dr. H. U. SVERDRUP, has been associated with the Department of Terrestrial Magnetism since last October in order to complete the reduction and publication of the magnetic observations thus far obtained by the Expedition. He will rejoin the *Maud*, Captain Amundsen's vessel, early in March at Seattle. It is expected that Captain Amundsen will resume his arctic expedition about June 1. During his brief stay in Washington, Captain Amundsen also paid a visit to the non-magnetic ship *Carnegie*. In the evening he met at the Cosmos Club a number of the scientific men of Washington with whom he discussed the plans of his arctic expedition, the chief object of which is to obtain scientific data relating to geography, oceanography, meteorology, gravity, terrestrial magnetism and atmospheric electricity.

AUGUST BUSCK has recently returned from an extended trip in the West

Indies, where he was investigating the pink boel worm of cotton for the Bureau of Entomology.

Mr. FULLER CLARKSON resigned from the Fixed Nitrogen Research Laboratory December 1, 1921, to accept a position in the research laboratories of the Procter and Gamble Company, Cincinnati, Ohio.

Dr. A. S. HITCHCOCK, of the Bureau of Plant Industry, returned on December 23 from a trip to the Orient where he went to study the grasses, especially the bamboos. He visited the Philippines, Japan, central and south China, including the island of Hainan, and Indo-China.

Representative ALBERT JOHNSON of Washington was appointed a regent of the Smithsonian Institution on January 4 by Speaker GILLETT of the House, and Representatives LEMMEL PADGETT and FRANK L. GREENE were reappointed as regents.

ADOLF TONDUZ, the well-known botanical collector in Central America, died at Guatemala City, Guatemala, in the latter part of 1921. Mr. Tonduz was a native of Switzerland, who received his early botanical training under Alphonse De Candolle, and emigrated to Costa Rica in early manhood. He was for many years connected with the Instituto Físico-Geográfico of San José, of which H. Pittier was director, and was associated with Mr. Pittier in a natural history survey of Costa Rica. His specimens are well represented in the U. S. National Herbarium and in the other large botanical establishments of the world.

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MINERALOGY.—*Sincosite, a new mineral.* (Preliminary note.)[1]
WALDEMAR T. SCHALLER, Geological Survey.

The name sincosite is given to a green hydrous calcium vanadyl phosphate, $CaO.V_2O_4.P_2O_5.5H_2O$, occurring in a black carbonaceous shale near Sincos, Peru. The mineral forms rectangular plates and is uniaxial negative. Some of the crystals are biaxial. Sincosite belongs to the uranite group of minerals (autunite, torbernite, carnotite, etc.) and illustrates the unexpected "equivalent valency" of quadrivalent vanadyl-vanadium with sexivalent uranic-uranium. Analysis of sincosite: CaO, 12.1 (calc. 12.33); V_2O_4, 36.3 (calc. 36.57); P_2O_5, 31.7 (calc. 31.28); H_2O, 19.9 (calc. 19.82); Insoluble, 0.3; total, 100.3. The full description of the mineral and a discussion of the relationships of all the minerals of the uranite group, will be published soon.

MINERALOGY.—*Cristobalite from the Columbia River Basalt of Spokane, Wash.*[2]
EARL V. SHANNON, United States National Museum.

Recently while engaged in studying the minerals contained in gas cavities in the Columbia River Basalt from Spokane, Washington, the writer has identified the rare mineral cristobalite in a number of specimens. Although all of the minerals of these specimens will be described in detail in the final paper, to be published in the *Proceedings* of the U. S. National Museum, it is desired here to call attention to this new occurrence of this rare mineral and to outline, briefly, the mineralogic features of the locality as indicated by the work thus far completed. The specimens were donated as a carefully selected series to the Museum by Mr. Henry Fair of Spokane, to whom grateful acknowledgment is here tendered.

The rock containing the minerals is the ordinary monotonous basalt of the vast Columbia River lava plateau and came from various street and railway excavations in the City of Spokane. The rock

[1] Received January 20, 1922.

[2] Published by permission of the Secretary of the Smithsonian Institution.

contains scattered cavities varying up to several inches in diameter, the first lining of which consists of small blade-like crystals of a plagioclase identified by its optical properties as oligoclase-andesine. Upon this crust rest the disseminated white crystals of cristobalite and minute octahedrons of magnetite following which was deposited siderite ("sphaerosiderite") in small spherical masses. Later successive deposits include, in the order named, pyrite, iron opal, second generation sphaerosiderite, calcite, white opal, and hyalite. Weathering has converted some of the nodules of siderite to secondary pseudomorphs of limonite and goethite.

The cristobalite forms sub-translucent white crystals 0.5 mm. or less in diameter irregularly scattered over the interior of the cavities. These have a feeble luster and a white porcelain-like appearance. It was possible to detach several of the cristobalites from the matrix and to measure them on the 2-circle goniometer with sufficient accuracy to identify the forms and to indicate isometric symmetry. Most of the crystals are cuboctahedrons with the faces of the cube and octahedron equally developed. The faces are commonly concave or divided by sutures so as to give several signals while the cube faces often show a confusion of slightly re-entrant angles suggesting complex twinning and grading toward the spherulitic forms characteristic of the mineral. Rarely a crystal is observed which shows no indication of this twinning and which has the exterior form of a simple isometric crystal. The best of these measured was a cuboctahedron with its edges beveled by narrow faces of the trapezohedron. The latter form has not previously been observed on crystals of this mineral.

Under the microscope the material has a feeble birefringence and has a refractive index of $1.485 \pm .003$. The crystals are unchanged by boiling in hydrochloric acid and are volatilized without leaving any residue by evaporation with hydrofluoric and sulphuric acids. Although cristobalite has recently been described from several localities in the United States this is the first locality in this country to furnish measurable crystals of this mineral.

CRYSTALLOGRAPHY.—*Review of the optical-crystallographic properties of calcium oxalate monohydrate.*[1] EDGAR T. WHERRY, Bureau of Chemistry.

The mineral whewellite, calcium oxalate monohydrate, was discovered in 1840, and has subsequently been the subject of considerable

[1] Received Dec. 3, 1921.

crystallographic and optical investigation. The literature contains, however, contradictory statements as to its optical properties. Definite data upon these properties being desired for use in the study of this compound as it occurs in plant tissues, the various papers have been critically reviewed. Crystalline fragments have also been studied by the immersion method, and the final conclusions as to the optical-crystallographic properties of the substance are here presented.

CRYSTALLOGRAPHY

Calcium oxalate monohydrate crystallizes in the holohedral class of the monoclinic system; its axial ratio a:b:c and axial angle β have been determined as follows.

Authority	Date	a	b	c	β	
Miller[2]	1840	0.8696	1	1.3695	72°	42′
Becke[3]	1907	0.8628	1	1.3677	73	00
Ungemach[4]	1909	0.8620	1	1.3666	73	02
Kolbeck, Goldschmidt & Schröder[5]	1918	0.8696	1	1.3695	72	42

The elaborate study of the mineral made by the last three authors appears to have definitely established the correctness of the Miller axial values.

The crystals are usually highly modified, but on the whole the base, the clinopinacoid and the unit prism are the dominant forms. A wide variety of habits has been noted. See figure 1. The most frequent appears to be prismatic, elongated on axis c, but elongation in the directions of axis a, axis b, and the zones of the pyramids (112) and (121) have also been observed. Tabular habits on the base, the clinopinacoid, and the dome (101) occur as well. Twinning is frequent on the negative unit orthodome (101). At all of its seven known localities the mineral is stated to be associated with some carbonate mineral, calcite, siderite, dolomite or ankerite, so that these habits represent the result of crystallization in an alkaline environment.

OPTICAL PROPERTIES

The values of the refractive indices for D light, α, β, γ, and optic axial angle 2 E given by different authors are tabulated here.

[2] Phil. Mag. (3) **16**: 450. 1840.
[3] Min. petr. Mitth. **26**: 391. 1907.
[4] Bull. soc. franc. min. **32**: 20. 1909.
[5] Beitr. Kryst. Min. **1**: 199. 1918.

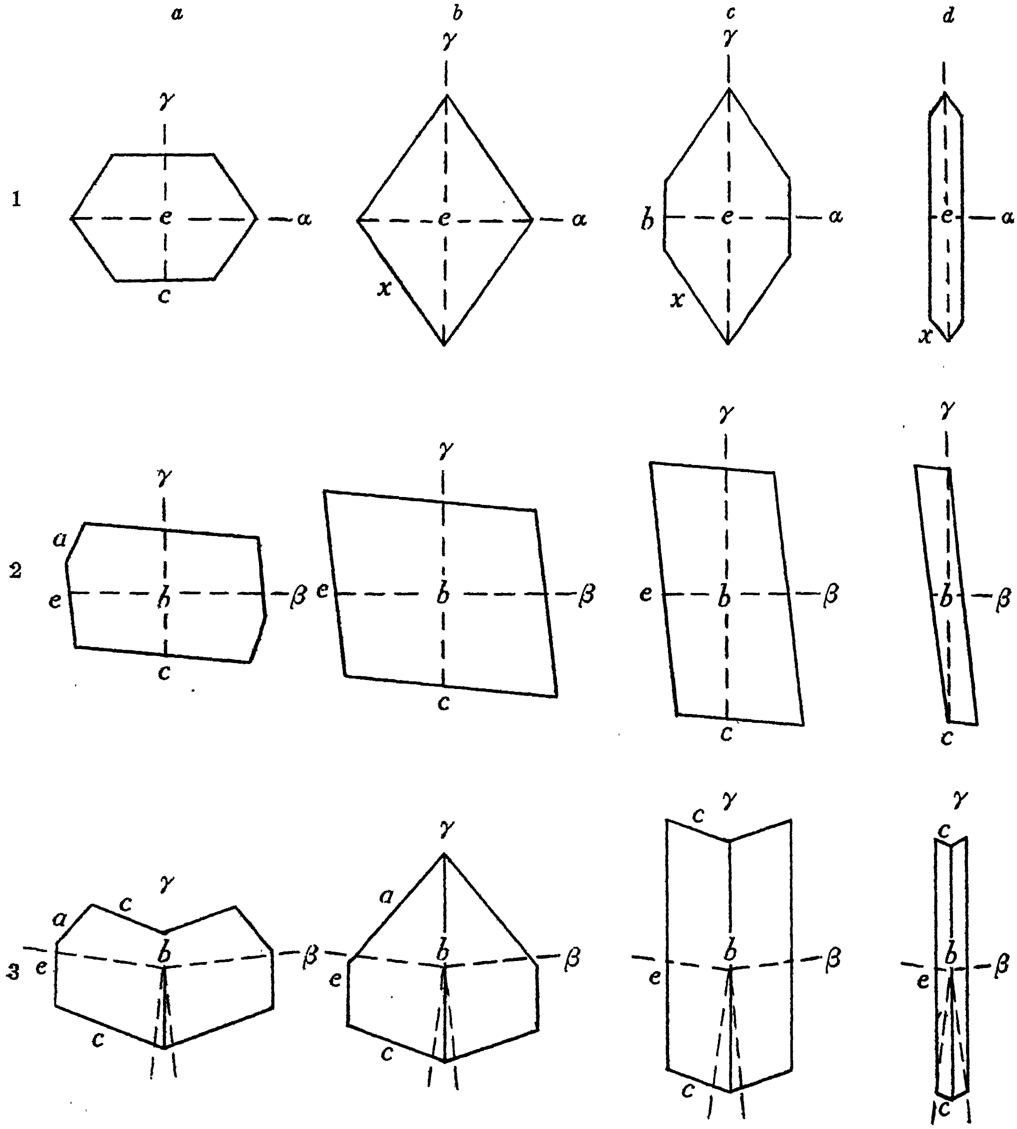

Fig. 1. Outlines of crystals of calcium oxalate monohydrate.

Authority	Date	α	β	γ	γ−α	2 E
Schubert[6]..........	1899	...	1.549	...	...	89°
Becke[7].............	1907	1.490	1.555	1.650	0.160	84° 40′
Ježek[8].............	1908	1.490	1.555	1.649	0.159	83° 42′
Ježek[9].............	1911	1.491	1.555	1.650	0.159	83° 55′
Average..........		1.490	1.555	1.650	0.160	84°

The values given by Becke and by Jezek agree within the limits of error of measurement, and the rounded average in the last line may be accepted as characteristic of the substance. Examination by the immersion method confirmed them completely. The material breaks into angular fragments without definite crystallographic orientation, so that values intermediate between the several indices are usually obtained, but the indices as given appear with sufficient frequency to show their correctness. The value of 2 E, as calculated from 2 V, is so high as not to be measurable under the microscope, but partial figures are often seen in the fragments studied by the immersion method, and on them the optical sign can be determined as positive, by the use of the selenite plate.

The greatest discrepancies in the literature upon whewellite concern the optical orientation, the following different descriptions of which are given:

Authority	Date	Position of axial plane	Position of acute bisectrix
Becke[10]	1907	Perpendicular to (010)	In obtuse angle β29° from axis *c*.
Ježek[10]	1908	"	...
Winchell[11]	1909	"	−11$^1/_2$° from axis *c*.
Groth[12]	1910	Parallel to (010)	In acute angle β64° from axis *c*.
Jažek[10]	1911	Perpendicular to (010)	In obtuse angle β30° from axis *c*.

Study, by the immersion method, of a number of samples, representing fragments of the mineral whewellite, crystals in the tissues of various plants, and crystalline precipitates prepared by boiling together dilute solutions of the constituent ions, has indicated that the data of Becke and Jezek are correct. In accordance with this interpretation of the orientation, the following features correspond to the more frequent habits:

[6] Min. petr. Mitth. **18:** 251. 1899.
[7] *Loc. cit.*
[8] Bull. int. Acad. Sci. Bohemia **13:** 1; **22:** 1. 1908; through Z. Kryst. Min. **46:** 610. 1909.
[9] Rozpr. Ceske Akad. II, **20:** 1. 1911; through Z. Kryst. Min. **54:** 191. 1914.
[10] *Loc. cit.*
[11] *Elements of optical mineralogy*, . 391, 1919.
[12] Chemische Krystallographie **3:** 152. 1910.

Refractive indices Lengthwise	Crosswise		Sign of elongation	Extinction angles	Twinning plane may show	Inferred habit—elongated on
α 1.490	β 1.555	γ 1.650	..	0°	Lengthwise	axis *b*
β 1.555	α 1.490	γ 1.650	±	0–13°	Crosswise or lengthwise	axis *a*
γ 1.650	α 1.490	β 1.555	+	0–30°	Diagonally	axis *c*
γ 1.650	α 1.490	β 1.555	+	0–6½°	Lengthwise	zone of *e* : *b*

These data are being applied to the study of the crystals of calcium oxalate occurring in official crude drugs and other plants, a report on which will appear elsewhere.

BOTANY.—*Two new species of* Acanthospermum *from the Galapagos Islands.*[1] S. F. BLAKE, Bureau of Plant Industry.

Several months ago I published[2] a revision of the genus *Acanthospermum*, a small group of *Asteraceae* closely related to *Melampodium*, from which it is distinguished technically by the presence of spines or hooked prickles on the indurated phyllaries which envelop the ray achenes. Of the eight species there described the most aberrant is *Acanthospermum lecocarpoides* Robins. & Greenm., the sole member of the Section *Lecocarpopsis*, which is distinguished from the two other sections of the genus by its pinnatifid leaves, plump trigonous-turbinate fruit bearing spines only around the broadly rounded apex, and comparatively large rays.[3] The species, seen by me only in two collections from Hood Island, Galapagos Archipelago, is remarkable for its rather close resemblance in every feature but the fruit to the monotypic genus *Lecocarpus* Decaisne, which is confined to Chatham and Charles Islands of the same group.

After the paper above referred to had been turned in for publication, I found at the Gray Herbarium two sheets of *Acanthospermum*, collected by Alban Stewart on Chatham and Gardner-near-Hood Islands, which appeared to represent two new species of the Section *Lecocarpopsis*. Through the kindness of Miss Alice Eastwood, I was able to supplement these two sheets by the extensive series of mounted and unmounted duplicates of the same two numbers in the herbarium of the California Academy of Sciences. Study of this material, amounting in all to 42 sheets, shows that it unquestionably represents two new forms of the Section *Lecocarpopsis*. Since these

[1] Received March 5, 1922.

[2] Contr. U. S. Nat. Herb. **20**: 383–392, *pl. 23*. 1921.

[3] The extreme corky-woody thickening of the fruiting phyllaries at maturity is also characteristic of this section of the genus.

forms, although closely related, are not connected by intermediates, they are here treated as species.

Since the days of Darwin's voyage on the Beagle, the Galapagos Archipelago has been a classical region for the study of the evolution of closely allied forms of both plants and animals. The three species of *Acanthospermum* here discussed make an interesting addition to the list of plant groups represented on different islands by distinguishable forms so closely related that their origin from a common ancestor, and presumably at no great distance in the past, is incontestable. The abundant material representing two of these forms, moreover, affords a basis for a greater degree of assurance as regards their probable distinctness than has often been the case previously.

As already mentioned, *Acanthospermum* is closely allied to *Melampodium*. *Melampodium* is an American genus of about 43 species ranging from Kansas to Brazil, and represented by one introduced species in the Philippine Islands, but not known from the Galapagos Islands. *Acanthospermum* includes, with the two species here described, ten species, native in the West Indies, South America, and the Galapagos Islands, and introduced in North and Central America and in the Old World. In both genera only the ray flowers are fertile, and each achene is closely enveloped and hidden by the corresponding subtending phyllary. The compound structures, called "fruits" for the sake of brevity, are armed in *Acanthospermum* with several or many spines or hooked prickles. In *Melampodium* the achene-enclosing phyllaries are smooth or merely tuberculate, and are in one section developed at apex into a cup or hood which may be prolonged into a single short or long often recurved horn on the apical outer margin.

The most remarkable character of the three species of *Acanthospermum* here considered is the variability in the armament of the fruits, a feature quite without parallel in the other species of the genus. In this respect *A. leptolobum* is by far the most variable. Although this species happens to be represented by far more material than the others (34 sheets, as opposed to 8 of *A. brachyceratum* and 2 of *A. lecocarpoides*), this cannot be considered the explanation of the variability, since the extremes represented in figure 1, *d-j*, are sometimes found in a single head. Especially noteworthy is the type of fruit represented in figure 1, *j*. Technically this fruit by itself would be referred to *Melampodium*. The absence of spines in this type of fruit seems to be due to a loss of vigor or nourishment, as indicated by the comparatively small size, and not to infertility, for the seed is quite

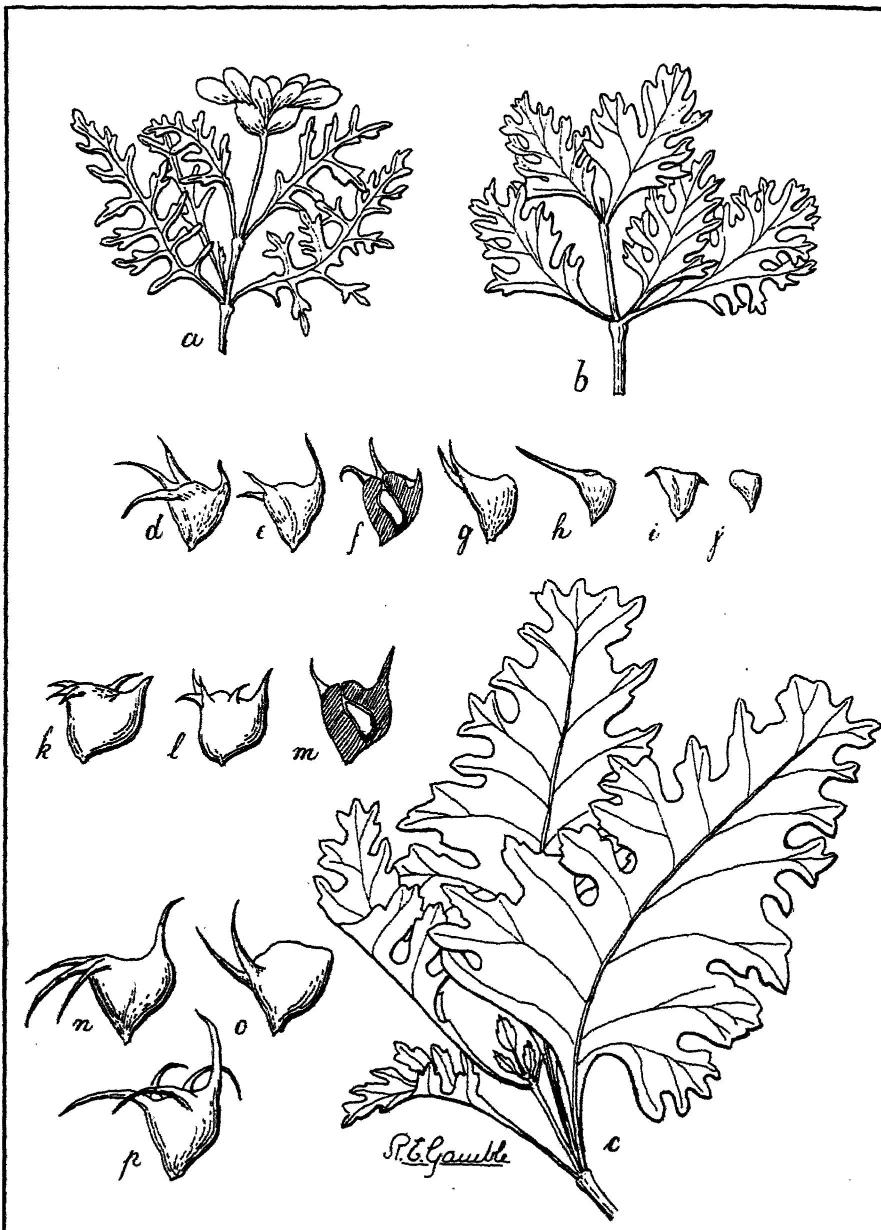

FIG. 1. Leaves and fruits of *Acanthospermum*.—*a*, *d-j*, *A. leptolobum*; *b*, *k-m*, *A. brachyceratum*; *c*, *n-p*, *A. lecocarpoides*. *a-c*, × 1; *d-p*, × about 2. All drawn from the types or specimens of the type collections. The ventral side of the fruits faces left in each case.

as well developed in such fruits as in normal ones. One is tempted to explain the variability of these three forms of *Acanthospermum* by the supposition of a very recent origin. The suggestion may also be made that the absence in the Archipelago of native mammals whose fur would provide a means of transport for the spiny fruits may be in some way correlated with the tendency to loss of spines. This tendency toward abortion of spines in the fruits of various unrelated genera of plants of the Galapagos Islands has already been mentioned by Robinson,[4] and considered explicable by the paucity of indigenous mammals.

The three species of the Section *Lecocarpopsis* may be separated by the following key.

Leaves usually divided about half way to midrib, the rachis 4 to 20 mm. wide; body of fruit 4 to 5 mm. deep; horns usually subequal, or the outer longer or rarely obsolete.

Leaf blades 4.5 to 9 cm. long, 2.2 to 4.5 cm. wide; peduncles 2.3 to 4.5 cm. long; horns of fruit 3 to 7 mm. long, usually subequal; Hood Island. *A. lecocarpoides.*

Leaf blades 1.5 to 2.5 cm. long, 1.7 to 2 cm. wide; peduncles about 1 cm. long; horns of fruit 1 to 3 mm. long, the outermost the longest; Gardner-near-Hood Island. *A. brachyceratum.*

Leaves divided nearly to the midrib, the rachis only 1 to 2 mm. wide; body of fruit 2.2 to 3.5 mm. deep; inner horns of fruit usually much longer than the outer; Chatham Island. *A. leptolobum.*

Acanthospermum brachyceratum Blake, sp. nov. Figure 1, *b*, *k-m*.

Base not seen; stem indurated, 60 cm. high, dichotomous, densely spreading-hispidulous; leaves opposite, hispidulous and gland-dotted above and chiefly on the nerves beneath; petioles 8 to 12 mm. long, connate at base, narrowly margined; blades oval-ovate, 1.5 to 2.5 cm. long, 1.7 to 2 cm. wide, obtuse, cuneate at base, lobed about to middle, the lobes 5 to 7 pairs, cuneate or oblong, revolute-margined, and toward apex 2 to 5-lobed with short obtuse densely hispidulous lobes; peduncles solitary, terminal, densely sordid-hispidulous, about 1 cm. long; heads 1.5 cm. wide; phyllaries 4, deltoid-ovate, obtuse, entire, hispidulous, 6 mm. long, 5 mm. wide; rays about 8, yellow, oval, tridenticulate, the lamina joined in a ring at base without proper tube, hispidulous and stipitate-glandular dorsally, 5.5 mm. long, 2.8 mm. wide; disk corollas numerous, yellow, the slender tube 1 mm. long, glandular, the campanulate throat 0.8 mm. long, the triangular acute recurved teeth 1 mm. long; pales acuminate, lanceolate, dentate at apex, stipitate-glandular above, about 3 mm. long; fruit turbinate, slightly compressed laterally, densely stipitate-glandular throughout and somewhat hispidulous, the body 4.5 to 5.5 mm. high, 4 to 4.5 mm. deep, bearing around the rounded apex 5 to 7 subulate horns usually grooved on the inner side, the 2 to 4 inner ones shorter, spreading or slightly ascending, 1 to 2 mm. long, the outermost one erect, with broadened base, 2 to 3 mm. high, the one or two lateral ones similar to the shorter inner ones.

Type in the Gray Herbarium, collected on Gardner-near-Hood Island, Galapagos Islands, September 28, 1905, by Alban Stewart (no. 701). Dupli-

[4] B. L. ROBINSON. *Flora of the Galapagos Islands.* Proc. Amer. Acad. 38: 238. 1902.

cates in the herbarium of the California Academy of Sciences and the U. S. National Herbarium.

Gardner-near-Hood Island, on which this species is found, is a tiny islet only 2 km. or less from Hood Island, the locality of *A. lecocarpoides* Robins. & Greenm. The two forms are very closely related, but *A. brachyceratum* may be distinguished by its much smaller, more finely lobed leaves, its shorter peduncles, and its shorter-spined fruit. It is described by the collector[5] as a common bush two feet high.

Acanthospermum leptolobum Blake, sp. nov. Figure 1, *a, d-j*.

Annual, dichotomous, about 1 m. high, the stem and branches slender, woody, grayish, densely tuberculate-hispidulous; leaves opposite, rather densely hispidulous on both sides; petioles about 8 mm. long, connate at base, narrowly margined, about 1 mm. wide; blades ovate, 2.5 to 4 cm. long, 1.3 to 4 cm. wide, pinnatifid nearly to midrib, the leaf rachis 1 to 2 mm. wide, the lobes about 5 pairs, mostly opposite, irregularly 2 to 8-lobed with linear obtuse segments or the uppermost entire, the segments again sometimes toothed; peduncles terminal, solitary, densely spreading-hispidulous with subglandular hairs, 1.3 to 2.5 cm. long; heads about 3 cm. wide; phyllaries 4, ovate, obtuse or acute, usually serrulate, hispidulous chiefly beneath, 8 to 10 mm. long, 4.5 to 6 mm. wide; rays 10, yellow, oval, tridenticulate, merely closed in a ring at base without proper tube, about 9-nerved, stipitate-glandular dorsally, 10 mm. long, 4.5 mm. wide; disk corollas numerous, yellow, the slender tube sparsely glandular, 1.5 mm. long, the campanulate throat 1 mm. long, the five recurved triangular teeth 1 mm. long; stamens cordate-sagittate at base; pales acuminate, lacerate-dentate above, stipitate-glandular, about 3 mm. long; fruit compressed-turbinate, densely stipitate-glandular and more or less hispidulous, whitish at maturity, the body 2.8 to 3.5 mm. high, 2.2 to 3.5 mm. deep at apex, bearing at apex 1 to 5 horns, the 1 to 3 inner subulate or lance-subulate, 1 to 4 mm. long, divergent-spreading, when large excavated at the base, or sometimes wanting, the 1 to 3 outer triangular to subulate, erect or curved-ascending, 1 to 4 mm. high, at least the central one excavated at base, the latter sometimes represented only by its deeply excavated base and without free portion, or all the horns entirely wanting.

Type in the Gray Herbarium, collected in woodland at Sappho Cove, Chatham Island, Galapagos Islands, altitude 240 meters, February 10, 1906, by Alban Stewart (no. 700). Duplicates in the herbarium of the California Academy of Sciences and the U. S. National Herbarium.

Chatham Island, on which this species occurs, is about 50 km. from Hood Island. Its representative of *Acanthospermum*, *A. leptolobum*, is so different from that of Hood Island that its specific distinctness is likely to be confirmed by future collecting, while the form found on Gardner-near-Hood Island, *A. brachyceratum*, is so much closer to *A. lecocarpoides* that it may prove to be only a variety. Stewart[6] describes his no. 700 as a common bush, 3 to 4 ft. high, in woodland at 800 ft., and says: "Except for the presence of spines on the achenes [fruits] the specimens from this island are more like *Lecocarpus*

[5] A. Stewart. *Botanical survey of the Galapagos Islands.* Proc. Calif. Acad. IV. 1: 148. 1911.

[6] Loc. cit.

foliosus than an *Acanthospermum*." I have not been able to verify his statement that some of the material from Gardner-near-Hood Island (*A. brachyceratum*) has "some of the leaves deeply cut, as do the specimens from Chatham Island."

In this species the slender stem is so woody that I was inclined to consider it frutescent, until a specimen was found among the unmounted material collected by Stewart which showed clearly that the plant was an annual.

In conclusion, it may be well to mention that the data for the specimens collected by Mr. Stewart on the 1905–06 Galapagos Expedition of the California Academy are in an unfortunate state of confusion. The 33 unmounted sheets of *A. leptolobum*, for example, are not accompanied by data, but they are so clearly identical in every feature with his no. 700 as represented in the Gray Herbarium and the herbarium of the California Academy of Sciences that I have no hesitation in considering them a portion of the same collection.

BOTANY.—*A perennial species of teosinte.*[1] A. S. HITCHCOCK, Bureau of Plant Industry.

In a recent article[2] entitled *Teosinte in Mexico,* Mr. G. N. Collins reviews our knowledge concerning teosinte in Mexico. Up to the present all the forms of teosinte have been referred to one species, *Euchlaena mexicana* Schrad. There are two forms of this, both annual, one from Durango, where it was collected by Dr. Edward Palmer, and one grown in Florida, the origin of which is uncertain. The latter form has been grown in France and may have come originally from Guatemala. At present the only known localities for the annual teosinte in the wild state are Durango and the State of Mexico near Chalco, where it was recently collected by Collins. The origin of the specimens described by European botanists is unkown.

The botanical history of the annual species is as follows:

Euchlaena mexicana Schrad. Ind. Sem. Hort. Goettingen. 1832; reprinted in Linnaea **8**: Litt. 25. 1833. I have not seen the original publication, an ephemeral seed list, but fortunately the reprint is accessible. Schrader describes the genus and species together, "*Euchlaena mexicana* Schrad. Nov. Gen. e Graminearum Olyrearum tribu," and so on. He describes the staminate spikelets as 1-flowered instead of 2-flowered and the genus is placed with the *Olyra* group. As to locality he says, "Mexico, Dr. Mühlenfordt." Nothing further concerning the history of this is known.

Reana giovanninii Brign. Ind. Sem. Hort. Mutin. 1849. The publication cited is also an ephemeral seed list which I saw at the Botanical Garden of

[1] Received March 20, 1922.

[2] Journ. Hered. **12**: 339. 1922.

Padua, Italy. Because of the rarity of the original publication the description is here reproduced.

Reana
Genus Novum
(Gramineae)
(Zeinae)

Flores monoici. *Masculi* terminales paniculati: spica biflora, flora altero sessili, altero pedicellato: staminibus sex. *Feminei* axillares, spicati, erecti, sessiles in axi flexuoso: bracteis imbricatis ad medium usque involuti: stylis longissimis, exertis, pendulis: parte spicae superiore, abortiva, exserta, erecta. *Cariopsis* curvo-trigona axe arcte adhaerens.

Reana Giovanninii foliis amplexicaulibus, canaliculatis, angustis, integerrimis, longissimis. Habitat in Mexico-Annua-Attulit ex loco natali D. Doct. Melchior Giovannini, Regiensis.

The description is quoted soon after in two botanical periodicals (Ann. Sci. Nat. III. Bot. **12**: 365. 1849; Flora n. ser. **8**: 400. 1850).

Reana luxurians Dureiu, Bull. Soc. Acclim. II, **9**: 581. 1872. The author in speaking before the society mentions a grass called Teosinte which he thinks is probably the name of a country. The seed probably came from Guatemala. He speaks well of it as a forage plant and ventures to call it *Reana luxurians*. The name is not technically published here as there is no description.

Euchlaena bourgaei Fourn. Bull. Soc. Bot. Belg. **15**: 468. 1876. In this article Fournier reviews the synonymy and describes the genus more fully than his predecessors. He describes three species, *E. mexicana*, *E. bourgaei*, and *E. giovanninii*, the second being new. He distinguishes the last species on description only, saying that he has seen no specimen with leaves as described. His new species is described as being 2 feet tall, annual, and the staminate inflorescence as consisting of a single terminal spike. The locality is given as "In collibus prope Chiquihuite (Bourg. absque numero), octobri." He gives the locality for his specimen of *E. mexicana* as "In arena fluvii exsiccati prope mare Pacificum, San Agostin, octobri (Liebm. n. 548)."

Euchlaena luxurians Dur. & Aschers. Sitz.-Ber. Ges. Nat. Freunde Berlin (session of Dec. 19, 1876); Bull. Soc. Linn. Paris **1**: 107 (session of Jan. 8, 1877). These two articles appeared about the same time and covered about the same ground. In a preceding article (*Ueber* Euchlaena mexicana Schrad. Verh. Bot. Ver. Brandenburg **17**: 76. March 3, 1876) Ascherson discusses the relation of *Euchlaena* to *Tripsacum*. He states here that the plants of *E. mexicana* were cultivated in the Berlin garden a few years and then disappeared. In the herbarium was a specimen from the garden and one deposited by Nees. Ascherson states further that there is no specimen in the herbarium at Göttingen to interpret Schrader's description. In the Trinius Herbarium at the Academy of Sciences, Petrograd, the present writer saw a fragment of "*Euchlaena mexicana* Schrad. e Hort. Goett."

In the first two articles mentioned Ascherson discusses at some length the history of the genus *Euchlaena*. He is familiar with *E. mexicana* as grown at the Berlin botanic garden. Previously the genus had been placed

near *Olyra* but he thinks it stands near *Zea* (Indian corn), in fact, that it resembles closely a stunted plant of maize. He points out that the staminate spikelets are 2-flowered instead of 1-flowered as described by Schrader; describes fully the female or pistillate spikelets and discusses the relation to *Tripsacum* and *Zea*, stating that *Euchlaena* is a *Zea* in which the female inflorescence is nearly as in *Tripsacum;* and quotes Grisbach (Veg. Erde 1: 542) as doubting the American origin of corn because of its affinity with certain Asiatic genera such as *Coix*, but Ascherson himself thinks *Zea* is much more closely related to *Tripsacum*, an American genus. Ascherson discusses *Reana luxurians* and takes occasion to transfer it to *Euchlaena*, of which genus he considers it a second species differing in its greater size. There are as many as 150 culms to one plant, these being as much as $2^1/_2$ meters tall. In the only staminate spikelet of *E. mexicana* he has seen the lemmas are shorter than the glumes while in *E. luxurians* they are as long as the glumes. The joints of the pistillate inflorescence are cylindrical and obliquely truncated at the ends instead of being triangular as in *E. mexicana*. This is the same difference distinguishing the Florida form of the cultivated teosinte from the Durango form as pointed out by Mr. Collins.

In 1910 I collected in Mexico, near Zapotlán, now called Ciudad Guzman, a perennial species of *Euchlaena*, and Mr. G. N. Collins collected it at the same place in October, 1921, while searching for teosintes in their native habitat. This species differs distinctly from all previously known forms of teosinte in the possession of rhizomes and is described below as new.

Euchlaena perennis Hitchc., sp. nov.

Plants perennial, producing strong scaly rhizomes; culms erect or somewhat geniculate at base, firm, glabrous, 1 to 2 meters tall; sheaths striate, the striae joined by numerous cross-veins, glabrous or some of them, especially the upper or those of the branches, somewhat hispid in the region of the collar and throat, the lower longer than the internodes, the upper shorter; ligule a short somewhat lacerate membrane, 1 to 2 mm. long; blades linear or linear-lanceolate, as much as 40 cm. long and 3 cm. wide, the upper shorter, somewhat cordate-clasping at base, acuminate, flat and rather thin, the white midnerve prominent beneath, glabrous, strongly scabrous or scabrous-ciliate on the margin, ciliate near the base; terminal inflorescence staminate, consisting of 2 to 5 approximate, ascending or spreading racemes 6 to 12 cm. long, the internodes between the lower ones about 1 cm.; spikelets in pairs, the pairs alternately to right and left on one side of a flat-triangular rachis, the rachis internodes 5 to 8 mm. long, scaberulous or ciliate on the angles; spikelets 2-flowered, 8 to 9 mm. long, elliptic or somewhat broader above, the middle one of the pair nearly sessile, the other on an angular scaberulous pedicel 3 to 4 mm. long, enlarged toward apex; first glume flat on the back, strongly inflexed at the margins, smooth except the scaberulous-ciliate keels, these somewhat winged above, slightly notched at apex. the midnerve rather faint, the strong lateral nerves at the inflexed margins, a second faint pair intermediate;

second glume a little shorter than the first, glabrous, convex on the back, loosely inflexed at the margins, thinner than the first, 5-nerved; lemmas and paleas all hyaline, the first lemma faintly 5-nerved, this and the 2-nerved palea about as long as the first glume; second lemma faintly 3-nerved, narrower and shorter than the palea, the latter nearly as long as the second lemma; pistillate inflorescences in the axils of the leaves, partly protruding from the sheaths, each wrapped in one or more sheathing bracts, consisting of a series of pistillate spikelets on an articulate axis, the spike being 3 to 6 cm. long and 4 to 5 mm. thick, in some cases bearing above a raceme of staminate spikelets as much as 10 cm. long; pistillate spikelets single, on opposite sides, sunken in cavities in the hardened joints of an obliquely articulate rachis; joints of the fruiting rachis trapezoidal, 6 to 8 mm. long, about 4 mm. thick the short side 2 to 3 mm. long; first glume indurate like the rachis joint, closing the cavity containing the remainder of the spikelet, apiculate, about as long as the joint, pilose in the sinus at base.

Type in the U. S. National Herbarium, no. 727077, collected in prairie along the railroad, about one mile south of the station, Zapotlán (Ciudad Guzman), Jalisco, Mexico, September 22, 1910, by A. S. Hitchcock (no. 7146). Also collected at the type locality October 28, 1921, by G. N. Collins and J. H. Kempton.

This species is distinguished by the rhizomes and scattered stems, the plants growing in colonies. The pistillate spikes appear to be usually single in the axils of the leaves.

ETHNOLOGY.—*Customs of the Chukchi natives of northeastern Siberia.*[1] H. U. SVERDRUP. (Communicated by Francis B. Silsbee.)

Captain Amundsen's Expedition left Norway in 1918 with the intention to follow the coast of Siberia eastward to the vicinity of Bering Strait, proceed thence towards the north, let the vessel, the "Maud," freeze in, and drift with the ice fields across the Polar Sea back to the Atlantic Ocean. The vessel was, however, forced by the ice conditions to winter three times in different places on the northern coast of Siberia, and was in 1921 compelled to go to Seattle for repairs.

In September, 1919, the Expedition was stopped by the ice at Ayon Island, about 700 miles west of Bering Strait. Natives of the Chukchi tribe, with herds of domesticated reindeer, were then living on the island, but they would leave the coast in a few weeks and move inland to the forests, where they are accustomed to spend the winters. This group of the Chukchi was apparently very primitive, and had very

[1] Abstract of an address delivered at a joint meeting of the Washington Academy of Science and the Anthropological Society, February 16, 1922; received for publication March 16, 1922. An extensive account, entitled "Blandt rentsjuktsjere og lamuter," has been published in ROALD AMUNDSEN's *Nordostpassagen.* Gyldendalske boghandel. Christiania, 1921.

little communication with the civilized world. Captain Amundsen realized that a unique opportunity was here afforded of gathering information about this little known tribe, and he therefore suggested that I join the natives, accompany them to the interior, and return to the ship in the spring. Thus it came about that I spent seven and one-half months alone among the Chukchi. The existence of the natives among whom I stayed depends absolutely upon the domesticated reindeer, which in winter live in the sheltered forests, where reindeer moss is abundant under the soft snow, and in summer seek the grass-covered tundra, where mosquitoes and hornets are less troublesome. Hunting is unnecessary for the natives, because the reindeer give them practically all they need—tents, clothes and food. In addition, they need seal blubber for their lamps, and sealskin for strings and soles. These articles they obtain from the natives at the coast in exchange for deerskin and deer meat. Furthermore, they go every spring to the Russian settlements at the Kolyma River to the yearly fur market, where they exchange their furs, mostly foxes and squirrels, for tea, tobacco, matches, knives, cartridges, and so on.

The tents in which they live, summer and winter, are very well adapted both to their nomadic life and to the climatic conditions. Their most striking feature is that they are double, one being inside another. The outer tent is large and almost conical, with a cover of reindeer skin. But if such a tent in cold weather were to be heated to a comfortable temperature, it would require a great quantity of wood. The Chukchi spend, however, only three or four months of the cold season in the forests, where wood is abundant; the rest of the year they live on the barren tundra, where they find willows to furnish sufficient fuel for cooking, but not for heating. Inside the large tent, therefore, they place a smaller one, used for living and sleeping. This inner tent is made of heavy deerskin, and has the form of a square case hanging down to the ground. It is lighted and heated by a flat lamp of the Eskimo type, but most of the heat is produced by the many people who gather in the small space. The temperature may rise to 80° F., even on a day when a blizzard is raging and the temperature outdoors is −20° F., because the inner tent is protected from the wind by the outer one, and because the reindeer-skins of which it is made are highly insulating. But at night, when the natives are sleeping on the ground, covered with deerskins, the temperature is liable to fall. Accordingly, before going to sleep, the natives adjust all the sides of the inner tent so that no holes are left through which cold air might

enter. The natural consequence is, that in the morning the air inside is frightful beyond description.

The Chukchi dress in deerskin only; they use one suit with the hairy side in and one with the hairy side out. The clothing of the men does not differ essentially from the clothing of the Eskimos, but the women's dress is entirely different. The Chukchi women wear high and very wide deerskin boots, and what may be called a union dress reaching to the knees. Ornaments on the dress are almost unknown; the only way in which the deer Chukchi try to give their dresses a more attractive appearance is by using white-spotted deerskins and matching them so that the white spots appear symmetrical.

The reindeer supply practically all the natives' food. A few roots are dug up in the spring and eaten, and the boiled contents of the reindeer's paunch is regarded as delicious, but with these exceptions, the diet is a pure meat diet. The Chukchi obtain the necessary variety in their food by eating almost every part of deer, from the meat to the marrow.

Furthermore, the reindeer are the beasts of burden; they have to pull the clumsy sledges on which all the belongings of the natives are packed, when they move from one place to another. When they are moving or living in the same place, the task of the men is to attend to the sledges, to keep the reindeer herd together, and the wolves away. The latter is the task of the young men, who sometimes lead a strenuous life. Occasionally it happens that for weeks at a time they do not sleep under shelter, while in the same time the elder men do not leave the tents. As soon as a man has a son, who is old enough to take care of the reindeer, he himself quits. The highest ambition of a man is, therefore, to have a son, or at least a son-in-law.

The young men handle the lassos with wonderful skill, and have an astonishing knowledge of the deer. The average number of reindeer belonging to one household is about 400 or 500, and a young boy knows by sight not only his and his father's reindeer, but also all belonging to the neighbors, which may mean several thousands. Curiously enough, he is not able to tell how many he knows, because the highest figure a Chukchi is able to handle seems to be 200—20 times 10. The task of the women is to tan the deerskins, make new clothes, mend old ones, to cook, and to do do what may be called general housework. The same rule applies to the women as to the men, namely, that the younger have to do the work, the older may do what they like.

The language has one peculiarity worth mentioning; it is pronounced in a different way by men and women. If a man uses a hard sound like *r*, *t*, or *k*, the woman often, but not always, replaces this with a soft *z*. To take one example. The word for sinew is pronounced by the men *rat-tet*, by the women *ze-zet*.

The chronology of the Chukchi is very simple; it does not exist. They do not count the years, so nobody knows his own age. They have, however, a word for "a year" and names for the different seasons and for the full-moons, of which usually 13 occur in one year. To enumerate the 13 months, the Chukchi count them on the 12 joints on both arms from the finger-tips to the shoulders, including the head for the thirteenth month.

Their social organization is almost as simple as their chronology. The Russian officials used to appoint one or two chiefs, whose main duty seemed to be to reconcile parties who were at odds. These chiefs had, however, very little to do, because the Chukchi really are governed by the unwritten laws of public opinion. These laws require in the first place, respect for old age, and forbearance towards the weak and poor. But they also open full opportunity for the young and hot-tempered to fight out their controversies. To fight an old man is regarded as one of the worst crimes. It is also regarded as unworthy of a man to beat a woman, unless she happens to be his wife.

The women are, however, generally well treated. The marriages are usually settled by the parents when the children are five or six years old, and a small number of reindeer is paid for the girl. She moves over to the tent of her future husband at the age of ten or twelve, but may have to return to her home if she is not able to get along with her mother-in-law. Single marriages are most common, but a few men have two or even three wives.

The Chukchi are accustomed to kill the old people. This is, however, no act of cruelty, but an act of mercy. When an old man becomes ill and is unable to leave the tent any more, than life becomes a burden to him and he a burden to his surroundings. He asks to be killed, and his son renders him the last service by stabbing him in the heart. The custom is barbaric, but the way in which the Chukchi treat their dead is still more barbaric.

The body is taken out to a lonely place where the ground is uncovered, and an oblong of large stones, with its axis in a southeast to northwest direction is made on the ground. The body is placed in this oblong with the head toward the northwest—towards the darkness,

and then the limbs are cut over at all joints up to the knee and elbow joint, the head separated, and several deep cuts made in the body. This is then covered with fresh deer meat. The dead has to have his sledge, ax, knife, tobacco pipe, and tea-cup with him. On the next day, the reindeer herd is taken to the burial place, a number of deer are killed, and their antlers gathered into a large heap northwest of the burial place. This ceremony is repeated usually three times at intervals of one year. Later, the relatives of the dead one will sacrifice a piece of meat or what they may have at hand, if they pass the burial place. If the dead one has expressed a particular wish for it, his body may be burned.

The religion of the Chukchi seems to be two fold. They have themselves no idols, but they keep a number of idols for the reindeer. Thus, the fire drills used in former times for starting a fire are regarded as some of the reindeer's idols. All ceremonies in which these idols play a part seem intended only to guard the reindeer from the dangers which surround them. Other ceremonies aim to guard the Chukchi themselves. They aim to keep away the evil spirits living in the Earth, or to reconcile them, and to seek help from the Sun, which seems to represent the good powers. In addition, the Chukchi pay attention to an endless series of small matters; their superstition is unlimited.

Their conception of the soul or mind is animistic. The soul develops with the body; an old man is highly estimated because his soul is great. At death, the soul separates from the body and goes to the northwest, where it lives a kind of shadow life. It can, however, communicate with the living, and the Chukchi believe that dogs act as links between the living and the dead.

Generally, the Chukchi are perfectly content with their existence; they have no desire to leave their country or change their habits. They do not care for the outside world, as long as this outside world is willing to bring tea and tobacco in exchange for fox-skins. Civilization would not bring them any good, so it would be well if they might remain as primitive as they are.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ENTOMOLOGICAL SOCIETY

338TH MEETING

The 338th regular meeting of the Society was held March 3, 1921, in Room 43 of the new building of the National Museum with President WALTON presiding and 28 members and 5 visitors present. New Members: WM. C. RICHARDSON, Richmond, Virginia; CHAS. C. HILL, Bureau of Entomology Laboratory, Carlisle, Pennsylvania.

Program

R. E. SNODGRASS: *Life-history of the resplendent shield-bearer of apple and of ribbed cocoon maker.*

Altogether popular in form this paper contained much of interest, being based on studies of the insect made in connection with the beautiful drawings with which the paper was illustrated. It was prepared for publication in the Annual Report of the Smithsonian Institution.

Notes and exhibition of specimens

Dr. DIMITRI BORODIN, the noted Russian Entomologist, was introduced to the society by Dr. HOWARD. Dr. BORODIN addressed the Society briefly in English and in Russian.

Mr. E. H. GIBSON called attention to a posthumous paper by the late OTTO HEIDEMAN, which was omitted from the bibliography of Mr. HEIDEMANN published in the Proceedings of this Society. This paper, *The Rhynchota of the Isle of Pines*, was published in 1917 in the Annals of the Carnegie Museum

Mr. WM. MIDDLETON announced the discovery by himself that the males of the sayfly genus *Xyela* belong to the group Stropandria, that is the genitalia are inverted. In this respect it differs from its nearest relatives.

Messrs. H. S. BARBER and H. E. EWING discussed the past history and recent finding of insects of the primitive order protura, the latter recounting in some detail the characteristics and affinities of the group.

Mr. E. R. SASSCER referred to the condition of French fruit and rose stocks which have arrived in the United States since January 1, 1921. He stated that in that period eighty-five nests of the Brown-Tail Moth had been taken in thirty-two shipments, in contrast with sixty-three infested French shipments which have arrived in this country during the last nine years. The finding of so many nests in such a brief period indicates that the French inspection service is much below the standard of previous years, and to meet this situation, all French shipments of rose and fruit stocks are now being fumigated at the port of entry under the direction of the Department of Agriculture, as well as inspected at destination by state inspectors. He further stated that a warning had been sent to the French nurserymen and French inspection service to the effect that if shipments continue to arrive infested with nests of this injurious insect, it may be necessary to cancel all existing permits to import French stocks.

Interceptions have been made by the state inspectors of Connecticut New York, Indiana, Iowa, New Jersey, North Carolina, Pennsylvania,

Maryland, and Federal Inspectors in New York City, Philadelphia, and Washington, D. C.

He also stated that these French shipments were found to carry a number of nests of the so-called White Tree Pierid, *Aporia crataegi* L.

Mr. A. B. GAHAN stated that owing to misdeterminations the insects hiterto known as *Thyreodon morio* (Fab.) and *Exochilum mundum* (Say) will have to be called *Thyreodon atricolor* (Oliver) and *Therion morio* (Fab.), respectively.

Dr. A. G. BÖVING discussed the larval structures of the rice water weevil, *Lissorhoptrus simplex*. In some respects, especially in the form of the spiracles which are forced into the air chamber of the rice stem, this larva is similar to that of *Donacia*. In most resects, however, it is like the other curculionids.

Mr. J. A. HYSLOP called attention to the recent death of Dr. CHARLES H. FERNALD, for many years head of the department of entomology at the Massachusetts Agricultural College.

339TH MEETING

The 339th regular meeting of the Society was held on April 7, 1921, in Room 43 of the new building of the National Museum, with President WALTON in the chair and 23 members and 5 visitors present. New Members: C. D. B. GARRETT, Cranbrook, British Columbia; Dr. W. R. THOMPSON, Villa Pina Flor, Auch, Gers, France.

Corresponding Secretary ROHWER announced that by action of the Executive Committee the Society is furnishing the Proceedings to foreign institutions already subscribing, which cannot afford to subscribe at the present rate of exchange, at the rate of exchange of 1914. Dr. WALTHER HORN of the Berlin Entomological Museum had taken advantage of this offer and in accepting it had also sent as a gift to the Society a set of photographs, many in duplicate, of European Entomologists. These were exhibited by Mr. ROHWER. Such of these as are not already in the voluminous collection of Dr. HOWARD are to be added to that collection and the others offered for sale.

Program

AUGUST BUSCK and CARL HEINRICH: *On the Male Genitalia of the Microlepidoptera and their systematic Importance.*

This paper showed how the different forms assumed by the various elements of the genitalia furnish the best characters for the classification and recognition of insects of this group. It was illustrated by many photographic lantern slides taken from the slide mounts of genitalia.

Mr. BUSCK also spoke of the finding in swarms by Mr. SCHWARZ at Plummer's Island, Maryland of the hitherto rare moth, *Ethmia macelhosiella* Busck, and the subsequent discovery of its host relations and life-history. These swarms were first observed by Mr. Schwarz on November 8, 1916, and in the following spring larvae found feeding on *Phacelia* developed into adults of this species. The larvae reach full growth early in May, pupate in bark, and emerge as adult moths late in the fall. The time and place of oviposition is not known.

In the discussion of the last Mr. E. A. SCHWARZ spoke of the somewhat

similar seasonal history of the weevil, *Dorytomus inaequalis*, the larvae of which feed in the catkins of cottonwood.

S. A. ROHWER: *Injurious and Beneficial Cynipid Galls.*

Mr. ROHWER discussed the various types of galls with especial reference to their relation to human welfare, and told of their use in the arts and of the investigations conducted during the war into the possible substitution of American galls for the ordinary galls of commerce. Lantern slides of many galls were shown.

Dr. A. D. HOPKINS spoke of a gall with deciduous grain-like cells which are much eaten by poultry and which analysis shows are much more nutritious than wheat. It is known as "black oak wheat."

340TH MEETING

The 340th regular meeting of the Society was held May 5, 1921, in Room 43 of the new building of the National Museum, with President WALTON presiding and 20 members and 1 visitor present. New members: PEREZ SIMMONS, Bureau of Entomology, Washington, D. C.

Program

A. B. GAHAN: *Phytophagous Chalcids.*

This was a list compiled from literature, of the phytophagous Chalcidoidea, not including the fig insects, and discussion of the probable evolution of the phytophagic habit.

The speaker showed that phytophagy was now said to occur in six different families of chalcid-flies, *viz.*, Agaonidae, Callimomidae, Eurytomidae, Encyrtidae, and Eulophidae. Seed Chalcids and joint-worm flies are not the only phytophagic forms. Certain species are definitely stated to be gall-makers and others are said to bore in plant tissue much as do certain Coleoptera, Diptera, and Lepidoptera. The list of food plants is a varied one embracing such widely separated botanical groups as Leguminoceae, Pomaceae, and coniferous trees. Many species are distinctly economic.

Not only are the phytophagous forms distributed through several families but in many cases they apparently do not offer even minor group characters by which they may be separated from parasitic forms. Phytophagous species of the genus Eurytoma can be separated specifically only with great difficulty from those known to be parasitic. Several other genera contain both plant feeding and parasitic forms. The phytophagous species belong almost exclusively to groups in which a large percentage of the related parasitic forms breed in host larvae which are concealed in plant tissue, as for example, gall-makers.

The speaker stated that the ancestors of the Chalcidoids were undoubtedly plant feeders and that parasitism was a subsequent development. Unless one believed that they arose from a source entirely separate from that of other insects and at a later date it is impossible to conceive of their always having been parasitic. Phytophagy as found in the group today, however, is believed to be a comparatively recent specialization. That this is probably true is demonstrated by the fact that although the Chalcidoids are apparently a plastic group exhibiting very numerous and slightly specialized forms, phytophagy is not confined to any particular group or groups but occurs sporadically throughout the whole superfamily. If phytophagy had long existed it is to be expected that it would have resulted in structural differen-

tiations between the forms so living and those which are parasitic. The most important indication of the probable recent development of the phytophagic habit, however, is found in the assertion by three different authors that certain species of Eurytomidae are parasitic in their earlier stages but finish their development as plant feeders. Such a mode of development would seem to leave little room for doubt that phytophagy as found at present is a recent specialization.

Notes and exhibition of specimens

Mr. L. H. WELD told in some detail of the collection of Cynipidae in the National Museum, its content and present arrangement. He stated that there are probably more Cynipidae in this museum than in any other institution.

Mr. S. A. ROHWER discussed the collection for the other groups of the Hymenoptera. He announced that the collection of bees had recently been completely rearranged, that the Serphoids were now being assembled and arranged; that the rearrangement of the sawflies was completed in 1911 but that since then much new material had been received; that the Chalcidoids were gradually being put in good order; and that in general the arrangement of the collection had been greatly improved in the last few years. He added there is still a very great deal to be done but that he believed the National Collection of Hymenoptera was probably more extensive than that of any other institution in the groups usually considered to be of economic importance. He pointed out that the material in the collection was in a large measure secured by the cooperation of the economic entomologists of the world and that because of this it represented much biological material and notes and that in this feature it was probably more complete than any of the large collections of other countries.

Mr. E. A. SCHWARZ spoke of four European species of *Carabus* that had been introduced into New England along with the *Calosoma* beetles. One of these, *nemoralis*, has now spread as far as New Jersey, while *auratus* has bred and spread more sparingly. The other two have apparently failed to establish themselves.

Dr. A. G. BÖVING stated that the National Museum collection of Coleopterous larvae is by far the largest in the world.

R. A. CUSHMAN, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

For the purpose of encouraging research work on glass the Research Committee of the Glass Division of the American Ceramic Society has made arrangements for providing glass of desired composition and desired form for investigators in this field. The material will be supplied free of charge and no limitations as to the nature of the research will be imposed. The recipients of the material will be under no obligations except that of publication of the results of their investigations. The committee, however, requests that whereever possible the Journal of the American Ceramic Society be given preference in reporting the results. Persons who are interested are requested to address their inquiries to one of the following members of the Committee on Research: E. C. SULLIVAN, Corning Glass Works, Corning, New York; E. W. WASHBURN, University of Illinois, Urbana, Illinois; R. B. SOSMAN, Geophysical Laboratory, Washington, D. C.

The Academy of Science and Arts of Trieste, Italy proposes to issue an encyclopedia of science and arts, under the editorship of Prof. GIORGIO GIUSEPPE RAVASINI DA BUÏE, of Istria. An advance notice states that the publication, which will appear in 16-page fascicles, will contain twice as many articles as the Encyclopaedia Britannica.

The Petrologists' Club met on March 14, with the following program: L. LA FORGE, *Magmatic differentiation as illustrated by the Dedham granitic group in eastern Massachusetts;* M. N. BRAMLETTE: Review of Gordon's *Desilicated granitic pegmatites;* E. S. LARSEN, informal communication on *Crystallization and resorption in magmas.*

Two small lots of bird skins presented to the National Museum by B. H. SWALES, Honorary Assistant Curator, Division of Birds, contain 8 genera and many species previously unrepresented in the collection.

The Section of Vertebrate Paleontology of the National Museum has recently acquired portions of the skin, hair, muscular tissue, dried fat and blood of the Siberian Mammoth, which, with other specimens, now form an exhibit illustrative of this animal. The specimens are from a carcass that was found frozen in a cliff along the Beresovka River in northeastern Siberia in 1901, and was exhumed for the Imperial Academy of Science in Petrograd by a Russian naturalist, now a refugee in Germany. The patch of skin measuring one by two feet is from the knee of the right hind leg. It is thickly covered with a short wooly hair and with bunches of long reddish hair that varies in length from 4 to 6 inches. A bunch of hair taken from the right shoulder has a length of more than 30 inches.

The Division of Mollusks of the National Museum has recently received from Dr. E. M. BLUESTONE, Assistant Director of the Mount Sinai Hospital, New York City, a series of 187 slides showing the different species of malarial parasites. In some instances specimens were taken at stated intervals between chills, to show the different stages in the development of the Trophozoite in the blood of man.

The grass herbarium has received a package of Brazilian grasses from the Berlin Herbarium containing a number of duplicate types collected by Sello and described by Nees von Esenbeck in his account of the grasses of Brazil published in 1829. A fine set of Argentine grasses has also been received from Dr. LORENZO PARODI, of Buenos Aires.

The Section of Photography of the National Museum has recently purchased a set of 75 representative photographs of snow crystals made by W. A. BENTLY, of Jericho, Vermont, who has been studying snow crystals for more than thirty years.

Dr. JOHN CASPER BRANNER, ex-president of Leland Stanford, Jr., University, California, and a non-resident member of the ACADEMY, died on March 1, 1922.

E. F. BURCHARD has taken leave for one year from the Geological Survey and has gone to Argentina for private interests.

MRS. AGNES CHASE of the Bureau of Plant Industry sailed March 11 for Europe to study the types of grasses in the larger herbaria. She goes first to Vienna to select a series of duplicates from the herbarium of the well-known agrostologist, Professor Hackel, and later will visit Florence, Berlin, Geneva, Paris, Brussels, Leyden, and London. Mrs. Chase expects to return about the first of July.

Prof. ARNOLD VAN JENNEP, eminent French anthropologist, was a recent visitor in the Division of American Archeology. Professor van Jennep

visited several sites of current investigation during his extensive journeys throughout the United States and is now on his way back to France.

F. J. KATZ, who has been with the Census Bureau for several years, has returned to the Geological Survey and will be assistant chief of the Mineral Resources Section.

Mr. A. S. LE SOUEF, director of the Zoological Gardens at Sydney, Australia, was a recent visitor at the Zoological Park. Mr. Le Souef took to Europe from Australia the first shipment of live animals sent abroad by the new Zoological Control Board of Australia, which now has complete charge of the exportation of Australian animals.

Dr. WILLIAM M. MANN, of the Division of Insects, who has been since last June with the Mulford Biological Exploration in eastern Bolivia and western Brazil, writes from Riberalta, Bolivia, under date of January 12, that the expedition will return to the United States early in April. Dr. RUSBY, the director, has recently been compelled to return on account of ill health. Dr. Mann is now in charge of the party.

Dr. MORTON P. PORSILD, of the Danish Arctic Station, Disko, Greenland, recently spent a day or two in study of the Alaskan collections of the National Herbarium.

T. W. VAUGHAN has at his request been relieved of administrative duties as Chief of the Coastal Plain Section in the Geological Survey, and L. W. STEPHENSON has been assigned these duties. W. P. WOODRING has been appointed Chief of the Section of West Indian geologic surveys in the Coastal Plain Section.

Dr. CHARLES W. WAIDNER, chief physicist of the Bureau of Standards, died on March 10, 1922 at his home, 1748 Lanier Place, after a long illness. Dr. Waidner was born in Baltimore, Maryland, on March 6, 1873. After graduating at Johns Hopkins University he acted as instructor both there and at Williams College. He was appointed to the Bureau of Standards in 1901 and made chief physicist in 1921 after the death of Dr. E. B. ROSA. Dr. Waidner's name is generally identified with his work on the high temperature scale, on radiation and on the resistance thermometer. More recently the other end of the temperature scale had also engaged his attention, to the advantage of our knowledge of refrigerating processes. During the war he had charge of the Bureau's work on aviation engines. He was a member of the ACADEMY and of the Philosophical Society, as well as of many national and international scientific bodies.

Dr. T. T. WATERMAN, lately appointed ethnologist of the Bureau of American Ethnology, has left for field-work in Alaska, Oregon, and Washington. He will first proceed to the Kasaan National Monument, Alaska, to study the architecture, totem poles and other objects at this village and will be accompanied by a half-breed Haida, related by marriage to Chief Skoul. It is expected that considerable legendary data bearing on history and sociology of the former inhabitants of Kasaan will also be collected. Should the results justify further work it is planned to continue field-work on place names and aboriginal village sites of Alaska to be followed later by work on stratigraphic archeology in more northern latitudes in order to discover if possible traces of the oldest Indians in this supposed prehistoric gateway of the migration of man into North America.

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PETROLOGY.—*The development of pressure in magmas as a result of crystallization.*[1] GEORGE W. MOREY, Geophysical Laboratory.

The explanation of the phenomena which take place in the cooling of molten magmas, whether forming intrusive masses or extrusive flows, is one of the principal functions of petrology. To such magmas all of the laws of the physical chemistry of mixtures apply, and the phenomena met with as these mixtures cool and solidify under the conditions found in nature are the result of the action of these physico-chemical laws. The elucidation of these phenomena in terms of the known laws of physical chemistry is made difficult both by the extreme complexity of the natural mixtures and by the general lack of knowledge as to the theoretical relationships of mixtures containing not only non-volatile components such as the silicate minerals but also volatile components far above their critical temperatures, such as carbon dioxide and water.

In this note attention will be directed to certain relationships between the temperature and composition and the vapor pressure of the volatile component, and especially to the relations between these quantities at temperatures approximating to the temperature of anhydrous fusion of the mineral components, and at very considerable pressure. At temperatures near that at which crystallization begins a liquid silicate mixture containing but a small amount of volatile component may exert but a comparatively small vapor pressure, but as crystallization proceeds with falling temperature the pressure of the volatile components will increase at a rapid rate: so rapid that a pressure many times the original pressure may result from the crystallization of but a small proportion of the non-volatile material. This relation holds true whether the original liquid mixture consists of water and a low melting salt such as KNO_3, or of water and other volatile substances with the usual non-volatile magmatic constituents; the

[1] Received March 27, 1922.

circumstance that the magmatic liquid is at a temperature far above the critical temperature of the volatile ingredients is without significance as long as any of the liquid phase remains in the system. The system H_2O–KNO_3 has accordingly been chosen to illustrate the relations between the variables, pressure, temperature and composition in a system containing both volatile and non-volatile components.

In a system such as H_2O–KNO_3 it is well known that the solubility or fusion curve is continuous from the eutectic or cryohydrate to the melting point of each component. This is illustrated in figure 1, C,[2] in which E is the eutectic, or cryohydrate, A_mE the freezing-point curve of water in equilibrium with solutions of increasing KNO_3 content, B_mE the freezing-point curve of KNO_3 in equilibrium with solutions of increasing H_2O content. While with mixtures rich in KNO_3 it is necessary to carry out solubility experiments inclosed vessels to prevent the escape of the water, KNO_3 and water are both components of all liquids in the binary system. This still holds true when component B has a melting point above the critical temperature of water, as is the case in magmatic solutions. The curves showing the vapor pressure of the saturated solutions given in figure 1, C are likewise continuous from the eutectic to the melting point of components A and B, respectively, and in the case of the solutions in equilibrium with the component of higher melting point, KNO_3, the curve must rise to a maximum pressure with increase in temperature, then on further increase in temperature the pressure must fall to the vapor pressure of the higher melting component at its melting point, or, more exactly, its triple point. This is shown in figure 1, B, in which the curve EB_m is the vapor-pressure curve of the solutions saturated with component B. As the temperature is increased, the vapor pressure of the saturated solution is determined by the balance between two opposing tendencies. One of these is the increase in vapor pressure of the water with increasing temperature; this is opposed by the decreasing water content of the solutions, and at the point of maximum pressure the two effects become equal. At higher temperatures, the second effect preponderates, and the pressure of the saturated solution decreases with increasing temperature. The actual ratio of the non-volatile to the volatile component at the point of maximum pressure is equal to the

[2] Fig. 1 is drawn to scale for the system H_2O–KNO_3, but the components H_2O and KNO_3 are represented by A and B, respectively, for the purpose of clearer discussion of similar relations in systems containing other components. Experimental details of the study of this system will be published soon.

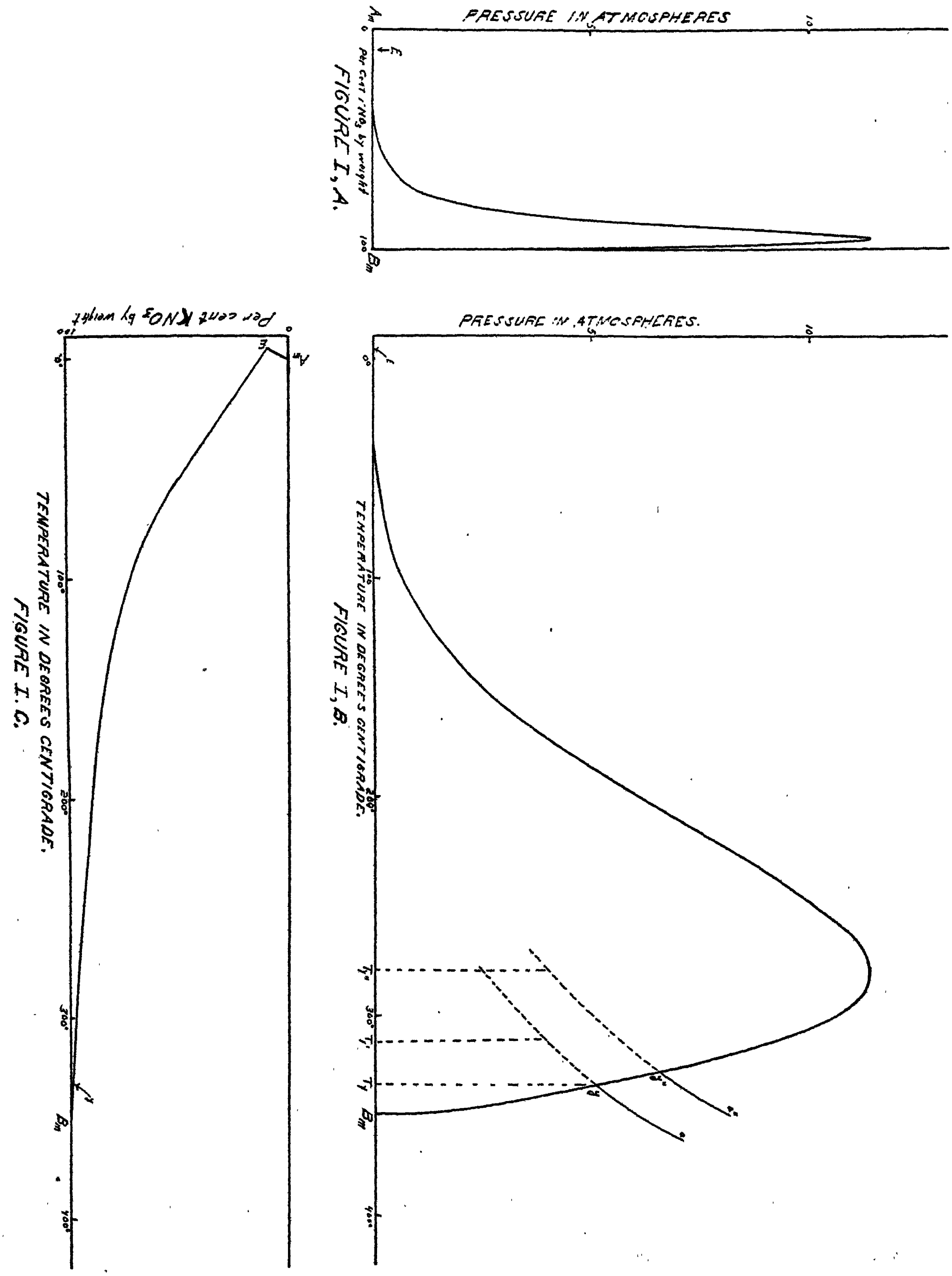

Fig. 1. Diagrams showing the change of the pressure, temperature, and composition of the univariant equilibria between solid, liquid, and vapor phases in the binary system H_2O–KNO_3.

ratio of the differential heat of vaporization to the differential heat of solution, and inasmuch as the former is always several times greater than the latter, the solution at this point will always contain but a small percentage of water; this is especially noticeable when composition is expressed as weight percentage, because of the low molecular weight of water. It follows from this fact that the pressure-temperature curve, EB_m in figure 1, B, will fall steeply from the point of maximum pressure to the melting point of the non-volatile component, in this case KNO_3.

In a binary system there are three variables to be considered, pressure, temperature, and composition of the liquid phase in equilibrium with crystals and vapor. In figure 1, C and B, are shown the relations between temperature and composition and between temperature and pressure; the relation between pressure and composition is shown in figure 1, A. The curve EB_m gives the vapor pressure of solutions of different composition in equilibrium with KNO_3 and vapor; the temperature to which a mixture of any composition must be heated to melt all but an infinitesimal portion of the crystals can be obtained from either B or C, figure 1. This curve shows in a striking manner the rapid increase in pressure consequent on but a small increase in the water content of the KNO_3 rich solutions.

If a mixture of composition y (figure 1, C) be considered at a temperature above that of the corresponding point on the saturation curve EB_m, its pressure will be represented by a point on the curve ay (figure 1, B). This curve ay gives the change in vapor pressure with temperature of the unsaturated solution of the composition y, and its slope will be large and positive, as shown in the figure. As the temperature is lowered the presssure will fall along the curve ay until the latter curve intersects the curve of saturated solutions EB_m. At this point crystallization will begin, and with further decrease of temperature the pressure will increase along curve B_mE in the direction of y''. The rapidity of increase in pressure, and the magnitude of the pressure ultimately developed, will in general depend on the solubility of water in the liquid. This effect may be made clearer by considering the matter from another point of view.

If liquid KNO_3 be cooled in an apparatus such that the liquid is kept in contact with steam at a pressure of one atmosphere, some H_2O will be dissolved, and this dissolved water will lower the freezing point of the KNO_3. If the pressure is kept at one atmosphere about 1 per cent of water will be dissolved, and it will lower the freezing point

of the KNO_3 about 3° C. With the liquid saturated at this temperature, suppose the apparatus to be closed in such a manner that the vapor space is very small, and the cooling to be continued, then crystallization of KNO_3 will begin at about 3° below its own freezing point. As the mixture cools, crystallization proceeds, the water content of the mixture increases, and its vapor pressure rises. Reference to figure 1, A or B, shows that at the time crystallization begins, the liquid composition is 99 per cent KNO_3, 1 per cent H_2O. When the water content has doubled, the pressure has increased from 1 atmosphere to over 6 atmospheres, a six-fold increase. When the water content has again doubled, reaching 4 per cent, the pressure has risen to almost 11 atmospheres. If the mixture be contained in a flask which can withstand a pressure of only 10 atmospheres, the flask will burst, as the result of the pressure developed by cooling the mixture.

Similar relations hold in silicate systems. It is now a demonstrated fact that water vapor under a pressure of one atmosphere is appreciably soluble in liquid silicates at their melting points, and that the amount of water dissolved at this pressure will produce an appreciable lowering of the melting point. In other words, the melting point as determined in steam at one atmosphere pressure is appreciably lower than that determined in air in the usual manner, just as was the case with KNO_3. In the case of anorthite, about 0.1 per cent of H_2O is dissolved, and the freezing point is lowered about 5°. If the initial pressure of water vapor is increased, more water will be dissolved and freezing will begin at a correspondingly lower temperature. In the case of KNO_3, increase in the water content from 1 to 4 per cent corresponded to an increase of pressure from about 1 to over 11 atmospheres. In the case of a system such as H_2O–SiO_2 the maximum pressure would probably be reached at a smaller H_2O content, and its magnitude would probably be enormous. Likewise, the pressure which would be developed by a magma containing but a small amount of H_2O, cooled in such a manner that this water could not escape, as is doubtless oftentimes the case, would be very great indeed.

Before considering this phase of the subject further, some known examples showing the reality of the phenomenon will be given. When liquid KNO_3 is saturated with water at one atmosphere pressure, and the mixture cooled, at a certain temperature solid KNO_3 will begin to separate from the liquid. If the vessel be open to the air, the pressure cannot rise above one atmosphere, so the water will pass off as steam; the liquid will evaporate to dryness, giving rise to solid and

vapor. Roozeboom gave the name "second boiling point" to this higher boiling point, which is obtained on cooling as above described. The second boiling point of a number of salt solutions has been observed by Smits, and others have been observed by the author. The "spitting" observed when molten silver is cooled in air is another example of the second boiling point, in this case in the system silver–oxygen, and a similar "spitting" was observed by Prandtl and Murschauser[3] with alkali vanadates. Jackson[4] gives an interesting description of a gas evolution on cooling on a much larger scale, which will be quoted:

"* * * * * * For a special optical glass, rich in phosphoric anhydride, an experiment was tried with ammonium phosphate to find if this substance could be used in the batch mixture for the glass. A nice, clear fluid melt was obtained, which was kept fluid for several hours after all traces of gas bubbles had gone. The melt was well stirred and cooled till it was quite viscous, when it was left to get cold slowly. The next morning the furnace top was found forced off, and resting on a spongy mass of about thirty times the volume of the original glass melt. The changes occurring when solidification was approaching had evidently been accompanied by the evolution of a large volume of gas, no doubt most of it ammonia, since this substance was smelt on grinding the spongy mass up. The ground material was then fused and gave a stable glass." This is probably to be explained by partial crystallization of the glass in the pot.

Experimental data exist for but one system which can fairly be taken as analogous to mineral systems, the system H_2O–K_2SiO_3–SiO_2.[5] The cooling of certain mixtures in this system will next be considered. With some compositions the second boiling point at atmospheric pressure can be demonstrated in a striking manner. If potassium metasilicate at its melting point be saturated with water at one atmosphere pressure, it takes up about 1 per cent, enough to lower its melting point about 35°. If the saturated liquid be cooled quickly it becomes supersaturated; the molten aqueous glass remains liquid until cooled several degrees below its melting point. First a few bubbles begin to form within the glass; then suddenly the bubble formation becomes rapid, the viscous melt swells into a pumiceous mass, increasing in volume many times, and overflowing the crucible. This is an example of the second boiling point at atmospheric pressure; of a boiling,

[3] Zeit anorg. Chem. **56**: 173–208. 1908.

[4] Sir HERBERT JACKSON, Smithsonian Report for **1919**, p. 245.

[5] MOREY AND FENNER. Journ. Am. Chem. Soc. **39**: 1173–1229. 1917.

attended by sudden liberation of vapor, taking place as a result of cooling.

A further example, illustrating, from the experimental results, the development of a fairly high pressure in a silicate system as the result of cooling, may be found in the same system. The eutectic between $K_2Si_2O_5$ and SiO_2 lies at the remarkably low temperature of 520°. If a mixture of K_2O, SiO_2 and H_2O, containing 9.1 per cent of H_2O, with the other ingredients in the molecular ratio SiO_2/K_2O = 4.26, be cooled from a high temperature, the vapor pressure of the mixture will fall as the temperature falls. The mixture will not begin to freeze until it has cooled to 500°, when crystals of quartz and the ternary compound $KHSi_2O_5$ will separate. The vapor pressure of the solution at this temperature is 160 atmospheres. On further cooling, the substances continue to crystallize and the pressure increases rapidly. When the temperature has fallen 20°, to 480°, the water content has increased to 10.2 per cent, and the pressure to 180 atmospheres. When the temperature has fallen to 420°, the water content has increased to 12.5 per cent, and the pressure to 340 atmospheres, more than double the pressure at 500°.

In discussing the crystallization of this mixture, it was assumed that crystallization started at 500°, the saturation temperature of the mixture, and the pressure rose from 160 atmospheres to 340 atmospheres continuously as the mixture crystallized on cooling. It is of interest to consider what would happen if the mixture were to cool without crystallizing, say to 420°, and then begin to crystallize. In figure 1, B, the curve *ay*, giving the change in pressure with temperature of the mixture of composition *y* in figure 1, C, is shown cutting the curve EB_m at a sharp angle; its metastable prolongation, shown broken in the figure, gives the change in vapor pressure that would take place if the mixture failed to crystallize. It is safe to assume that this curve has a steep slope. Similarly, if the mixture in the ternary system were to supercool, its pressure would diminish rapidly, and the amount of the diminution can be estimated. The vapor phase consists of water only at a pressure of 160 atmospheres. Pure water has a vapor pressure of 160 atmospheres at 348°, and it is probable that the two vapor-pressure curves will be roughly parallel, with the curve of the saturated solution possibly falling more rapidly than that of pure water. On the assumption that the drop in pressure for the 80° drop in temperature from 500 to 420° in the solution is the same as the drop in pressure of water from 348° to a temperature 80° lower, the vapor pressure of

the supercooled liquid at 420° will be 59 atmospheres. If the mixture containing 9.1 per cent water were to cool, without crystallizing, from 500°, its saturation temperature, to 420°, its pressure would fall from 160 atmospheres to about 50 atmospheres. If at this lower temperature it should begin to crystallize the pressure would suddenly rise to that of the solution in equilibrium with quartz and $HKSi_2O_5$ at 420°, or 340 atmospheres.

It is evident, then, that as a magma containing water and other volatile components cools, with consequent crystallization, the pressure will rapidly rise from its initial value, and as the cooling continues the pressure will increase until the temperature of maximum pressure has been reached, or until the pressure is relieved by escape of the volatile material. In the first case, which is that in which the liquid cools under a crust of sufficient weight and strength to withstand the internal pressure, the liquid will solidify as an intrusive mass. In the case of an actual magma the fact that water has a critical temperature at 374° C. has no significance, because of the probability that enough material will remain in solution to raise the critical temperature of the mixture the requisite amount. The water, containing in solution residual material such as dissolved gases, boric acid, sulfur, and probably some alkalies, will be available for metamorphic processes.

In the second case, that in which the liquid cools under an incompetent crust, when the pressure has reached a certain limiting value it will force open a vent for itself, possibly giving rise to a volcanic eruption. The phenomenon observed in any particular eruption will depend, in large part at least, on the magnitude of the pressure and on the composition of the non-volatile portions of the magma, though these factors may not be independent. If the vent is a fairly open one, enormous pressures probably will not be developed and the escape of the water as steam may be comparatively quiet; this will presumably be the more probable in the case of a very fluid lava. The mild explosive activity of Stromboli and the yet milder bubbling of Kilauea may be examples of this type. It may well be that in both these cases the activity is the result of the release of volatile material consequent on crystallization, and the rate of release of the volatile material may be regarded as a measure of the rate of crystallization in the parent body. The difference in violence in the two cases may be determined solely by the depth at which crystallization is taking place, and by the size or tortuosity of the channel through which the material must pass.

On the other hand, conditions may be such that a much greater pressure must be developed before the gases are able to force their way to the surface. It may be assumed that eruptions will then take place at less frequent intervals, since more time must elapse for the cooling process which occasions the crystallization, and that, on account of the greater pressure, the resulting eruptions will tend to be catastrophic. In a previous paragraph it was stated that in the case of an incompetent crust the building up of pressure as the result of cooling and crystallization would continue until the pressure was relieved by the escape of the volatile material. It might be that, if the crust were of sufficient strength, a fairly large proportion of the liquid magma would crystallize before a pressure had been built up of sufficient magnitude to cause an eruption. These conditions may determine the formation of a new volcano, such as Monte Nuovo, Jorullo, or Chinyero, and may also explain the renewed activity of a volcano whose vent has been plugged by solidified lava. In such a case, in which a considerable amount of crystallization has taken place, the non-crystallized material ejected will represent the "mother liquor" remaining after the segregation of those minerals which are the first to crystallize under the conditions prevailing. These may be the femic minerals; in which case the mother liquor will be enriched in the more salic minerals, quartz and the feldspars, and the water content will be correspondingly increased.[6] The tendency for the heavier femic minerals to differentiate by settling will be great, especially since the density difference between the femic and salic minerals will be increased by the presence in the salic melt of the accumulated water. We should therefore expect, irrespective of the original composition of the magma, that paroxysmal eruptions would be characterized by the ejection of salic lava. The presence or absence of traces of the differentiated materials will be erratic, depending on the completeness of the differentiation in relation to the original situation of the material examined. Moreover, since the salic lavas are in themselves, when freed from water, viscous even at their melting points, and since the temperature at this stage will have been greatly lowered, on the sudden expansion following the disruption of the restraining crust, the ejected material will be shattered into small fragments. It will be seen that the above conclusions are in accord with the well-known characteristics of catastrophic eruptions; salic

[6] N. L. Bowen. *The later stages of the evolution of the igneous rocks.* Journ. Geol., Suppl. to Vol. **23**, No. 8. 1915.

ejecta, highly vesiculated, containing large amounts of glassy material, ejected by violent explosions following long periods of quiescence. The well-known cases of Bandai-San, Krakatoa, and Martinique may be cited as illustrations. Material ejected from Krakatoa "was so vesicular that it floated in the water, accumulating here and there in great banks which covered the sea for miles, rising sometimes to a height of four or five feet above it,"[7] and the ejecta still contained considerable water, as well as much glassy material.

In the above discussion the question of the source of the water has not been considered. Doubtless the original magmas contain water, but whether or not this is augmented by accession of meteoric water is an open question. The often cited proximity of active volcanoes to large bodies of water may be regarded as evidence of the probability of such accession, and in some instances the case for the absorption of meteoric water is strong, but it may not be true in the majority of cases. It has been demonstrated by Johnston and Adams[8] that the phenomenon of capillarity does not furnish a mechanism for the introduction of water into magmas, and they have shown that the often cited Daubree experiment has no bearing on the question at issue. As previously stated, crystallization and differentiation will result in the accumulation of water in the residual magma, and such accumulation probably is competent to explain the production of those pitchstones which contain water sometimes up to 10 per cent. Irrespective of the relative importance of original and meteoric water, it is believed that the relations which have been outlined furnish a mechanism by which water can enter a magma. Not only is it possible for a magma to take up water, but the water may be taken up by the magma under a small pressure head and later liberated with the development of high pressure.

It has already been shown that in a crystallizing magma the water accumulates in the liquid phase. If a magma, either deficient in water or containing but a small amount of water, and above its crystallizing temperature, be in contact with porous water-containing strata, it will absorb water vapor until its water content corresponds to the prevailing temperature of the magma and to the pressure of water vapor. The portion of such a stratum near the volcanic neck will be at a high temperature, and the water in this portion will be in the form of steam; the cooler portions farther removed will contain liquid water, and be-

[7] T. G. Bonney, *Volcanoes*, p. 24. The Science Series. G. P. Putnam's Sons, 1899.
[8] J. Johnston and L. H. Adams. Journ. Geol. **22**: 1–15. 1914.

tween will be a surface at which the water is boiling. The location of this zone of boiling will be determined by the hydrostatic head of the water; if the head is about 3000 feet, the hydrostatic head will be about 100 atmospheres, and the zone of boiling will be removed to a region in which the temperature is about 310°.

When the magma crystallizes, the water dissolved in it at a pressure of 100 atmospheres will be concentrated, and the pressure may increase to a high value, as previously explained. If eruption, with release of pressure, takes place, we have the water, absorbed under a pressure of 100 atmospheres, being released under a pressure many times 100 atmospheres. The crystallization may take place at some distance from the point of entry of the water, under conditions such that the back pressure developed by the crystallizing liquid does not reach the porous strata which were the source of the water, or the suddenness with which the pressure is developed may be such that the tortuous channels in the porous strata offer a greater resistance to its release than does the overlying crust or lava column. It is highly probable that if such lava were to be forced into the water-saturated porous strata it would effectually seal itself by rapid cooling in the pore spaces.

The solubility of water in a silicate melt at a given pressure of water vapor will depend largely on the temperature, and it is to be expected that the solubility will increase with decreasing temperature, for the same reasons that gases are more soluble in cold water than in hot water. If an undercooled silicate mixture, that is, a mixture which had remained liquid altho it had cooled below the temperature at which crystallization should have taken place, were to come into contact with water vapor, say at a pressure of water vapor of 100 atmospheres as before, it would probably take up a much larger quantity of water than at a high temperature. Reference to the curve *ay* in figure 1, C will illustrate this point.

When the mixture of composition y is cooled, at T_y its vapor pressure is 5.1 atmospheres; if it be undercooled to T_y', its vapor pressure will fall to 4 atmospheres. If a mixture richer in water is undercooled, its pressure will fall to 4 atmospheres at a lower temperature, T_y''. Similarly, the pressure of 4 atmospheres will correspond to progressively lower temperature for mixtures of increasingly greater water content. If, now, liquid KNO_3 be undercooled to T_y'', under a water-vapor pressure of 4 atmospheres it will dissolve not the amount of water it would have dissolved at its saturation temperature T_y, but the larger amount corresponding to the mixture whose melting point

is T_y''. If crystallization be now induced, there will be a sudden development of a pressure, corresponding to the saturation pressure at T_y''; the water introduced into the melt at a pressure head of 4 atmospheres will be released at a much higher pressure, in this case about 11 atmospheres. If an undercooled magma were to come into contact with percolating waters, or the vapor generated therefrom, as previously explained, a similar introduction of water at a low pressure might take place. Introduction of this water might of itself induce crystallization in virtue of the lowered viscosity of the resulting magmatic solution, and it is conceivable that the result would be a sudden and violent outburst of steam and ash, at a comparatively low temperature.

SUMMARY

It has been shown that when a system composed of volatile and non-volatile components such as water and KNO_3 is cooled, crystallization will take place at a temperature lower than the freezing point of the pure non-volatile salt by an amount corresponding to the amount of volatile material present, and that the corresponding three-phase pressure increases rapidly as the temperature is lowered from the melting point of the salt. This increase is rapid whether measured in terms of the decrease in temperature of the three-phase equilibrium or in terms of the content of volatile material in the solution. From the latter fact it follows that in systems of the type of magmas, in which the non-volatile material is composed of such substances as the silicates, and in which the pressure required to retain any considerable proportion of water in solution must be large, a comparatively small amount of crystallization will result in a large increase in pressure. When a magma containing water cools, with consequent crystallization and development of high pressure, under an incompetent crust. a release of pressure will take place, which may be catastrophic in violence or take the form of a succession of mildly explosive outbursts. In case the magma cools under a competent crust the pressure will rise to a maximum, and then decrease, probably without at any time showing critical phenomena.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY[1]

622ND MEETING

The 622nd meeting was held in the lecture hall of the Cosmos Club, on March 5, 1921 at 8 p.m. Vice President A. S. HITCHCOCK presided, and 32 persons were present. Upon recommendation of the Council Mr. M. A. MURRAY was elected to membership.

Brief notes

Mr. IVAR TIDESTROM exhibited two books. One was 202 years old, had seen constant usage, and was still in excellent condition; the second book, somewhat more than a year old, was in poor condition, both as to binding and the printed pages. The first book illustrated the durability of rag paper as compared with the pulp paper now commonly used even in reference works. DR. PAUL BARTSCH cited the deterioration of a book lying exposed from Saturday to Monday.

Dr. H. C. OBERHOLSER stated that the whistling swan, which had returned to nearby waters for four or five years past, after an absence of twenty years, were seen this last winter in increasing numbers. Dr. PAUL BARTSCH stated that Holboell's Grebe had been observed recently in the Tidal Basin; also that nineteen species of spring flowers had been reported at a recent meeting of the Wild Flower Preservation Society.

Formal program

H. M. HALL: *The synthetic method of botanical taxonomy.*

Botanical taxonomy has not much to its credit in the way of past achievements. At present it is at a nearly static or stationary stage in its evolution. In order to make it dynamic and progressive more attention should be paid to three phases of the subject.

(1) The development of a philosophic aspect. Relationships of phylogeny should be taken as the guiding principle in all taxonomic work. Analytical methods now employed should be combined with synthetic methods having as their aim the organization of these small units into larger natural assemblages, the data for such work to be obtained from comparative morphology, paleontology, ontogeny, and geographic distribution.

(2) The development of new methods. The present observational descriptive, and qualitative methods may well be replaced by methods that are experimental, quantitative and exact, thus elevating systematic botany to the stage of a true science.

(3) The development of a new method for the expression of results in a concise and readily intelligible manner. The use of diagrams to illustrate phylogeny is advised. More important is the development of a system of nomenclature that will express both the names of plants and their relationships. It is therefore recommended that the term "species" be used in the original comprehensive sense, that only these inclusive units or true species,

[1] Reports for the 627th and 628th meetings were published in this JOURNAL **12**: 188–191. 1922.

be given binomials, that the principal subdivisions be treated as subspecies or varieties, and that still smaller units, such as those of the geneticist or other specialist, be treated in any other manner that meets the special requirements. In this way the number of species will be kept within reasonable bounds, the varietal category will provide for those who desire to go one step farther. and the recognition of even the smallest possible unit will not be excluded.

The paper was illustrated by lantern slides of plants, and tables showing the application of the suggestions which were made. The paper was discussed by Major E. A. GOLDMAN and Drs. P. BARTSCH, T. S. PALMER, F. W. COVILLE, and W. E. SAFFORD.

623RD MEETING

The 623rd meeting was held March 19, 1921 at 8:10 p.m., in the lecture hall of the Cosmos Club. President HOLLISTER was in the chair and 50 persons were present.

Informal communication

Dr. F. H. KNOWLTON stated that during the last ten years, for three of the spring months, continuously during the daylight hours a cardinal would fight his reflection in the windows of the speaker's house. The bird has been known to launch himself at the windows 26 times in five minutes. It is not known that it is the same bird which has been under observation during these years.

Formal program

F. H. KNOWLTON: *The flora of some newly discovered beds in southern Colorado.*

For fifty years highly fossiliferous deposits have been known in the Tertiary lake beds of Florissant, Colorado. Insects, plants, and birds, fish and shells are preserved with remarkable fidelity in the volcanic ashes and mud filling the lake. Other similar deposits have been found in Colorado, the largest near Creede. Among the plants found are pines, firs, grape, currant, poplars, flowers and fruit believed to be a raspberry, etc. Specimens were shown in the thin papery shales into which the rock breaks up. The paper was discussed by Messrs. ROHWER, HOPKINS, and HITCHCOCK.

H. C. OBERHOLSER: *The breeding water fowl of the Great Plains region.*

For several years the breeding grounds of water fowl in the United States were studied by the Biological Survey to secure data for the administration of game protection laws. The greatest breeding ground in the United States is in the State of Nebraska and the States northerly from it. Still greater areas exist in Canada. For many years the water fowl suffered from the draining of their feeding and breeding grounds, and by killing for sport and the market. Tens of millions of birds were sacrificed annually. Dr. Oberholser described and illustrated with lantern slides many of the lakes of the region used as breeding grounds of water fowl, and nests and birds were shown of several of the species. The paper was discussed by Dr. SHUFELDT.

624TH MEETING

The 624th meeting was held jointly with the WASHINGTON ACADEMY OF SCIENCES on April 2, 1921, in the lecture hall of the Cosmos Club, at 8:15 p.m. ALFRED H. BROOKS, President of the ACADEMY presided, and 75 persons were present.

Dr. A. D. HOPKINS, Retiring President of the Biological Society, delivered an address on *Intercontinental problems in natural and artificial distribution of plants.* An extended abstract of Dr. Hopkin's paper has been published in the JOURNAL OF THE ACADEMY.[1]

A. A. DOOLITTLE, *Recording Secretary.*

625TH MEETING

The 625th meeting of the Biological Society of Washington was held on April 16, 1921 in the lecture hall of the Cosmos Club, at 8:15 p.m. President HOLLISTER was in the chair and 66 persons were present.

Informal communications

H. C. OBERHOLSER: *A note on Miss M. T. Cooke's* Birds of the Washington Region, *published by the Society.*

Formal program

F. C. LINCOLN: *The Fall migration of ducks from Lake Scugog, Ontario.* Interesting results have been obtained from the work on the Bureau of Biological Survey in banding wild ducks trapped at Lake Scugog, Ontario. Last summer about 225 ducks were banded, mostly mallards and black ducks, with a few blue-winged teal and ringnecks. The Biological Survey has already received reports of the killing of over 35 of these ducks or about 16 per cent.

Some were killed close to Lake Scugog, but others were from such distances as to clearly indicate the route these birds travel on their pilgrimage to the Gulf Coast. In the Mississippi Valley bands were returned from points in Ohio, Indiana, Kentucky, Tennessee, Arkansas, Mississippi, Louisiana and Texas. On the Atlantic coast no birds were reported from regions north of Chesapeake Bay, but south of this point the route is well connected, showing that these birds migrate in a southeasterly direction across the Alleghanies to the Atlantic coast.

Bands have been returned from Virginia, North and South Carolina, and Florida. The most interesting note was received through the State Department from the American consul on the island of Trinidad. The band had been placed on a blue-winged teal at Lake Scugog on September 24, 1920, and was recovered through a local hunter near Port of Spain, Trinidad, on December 9. (Author's abstract.)

The paper was discussed by Dr. A. S. HITCHCOCK.

E. W. NELSON: *Alaska and the reindeer industry.*

THOS. E. SNYDER, *Recording Secretary pro tem.*

626TH MEETING

The 626th regular meeting was held April 30, 1921, in the lecture hall of the Cosmos Club, at 8:15 p.m. President HOLLISTER was in the chair and 51 persons were present.

Informal communications

M. W. LYON: *Note on buffalo or bison raising.* This note was illustrated with a lantern slide of a carcass of a pure bison calf exhibited in front of a restaurant in South Bend, Indiana.

T. S. PALMER: *Note on the status of bison in the United States.* One large herd which was becoming unprofitable was disposed of by letting sportsmen shoot the animals at $250 per head. There are a thousand head on the market

[1] This JOURNAL **11**: 223–227, 227–229. May 19, 1921.

in South Dakota. In New Hampshire they are occasionally on sale. There are two herds in Oklahoma with occasional sales. There were 8000 bison in the United States last year.

Dr. R. E. COKER exhibited copies of the new *Journal of Ecology*, which is a continuation of *Plant World*, but whose scope is to include both plants and animals.

Dr. PAUL BARTSCH referred to the column in the *Washington Herald* entitled Scientific Notes and Comments. A motion approving the column was carried.

Dr. C. C. ADAMS, Director of the Roosevelt Wild Life Experiment Station, spoke of the inception of the movement to perpetuate the memory of Theodore Roosevelt. The station established is a research station.

Formal program

J. N. ROSE: *Rediscovery of a remarkable cactus from Haiti.* For more than a century a cactus growing in Haiti has been known only from a drawing in the British Museum over the title *Cactus caniculatus*. No additional information was obtained until 1917 when a specimen was brought to this country by Dr. PAUL BARTSCH. Later Dr. C. G. ABBOT visited the region, and made complete field observations and collections, so that the plant is now pretty well known. A monograph of the species had been prepared in which the species is redescribed as *Neoabbotia caniculatus*. Some remarkable features are that it is the largest known cactus and its blossoms are in clusters. Photographs of the plant were exhibited. The paper was discussed by Dr. LYON and Dr. BARTSCH.

JOSEPH GRINNELL: *The principle of rapid peering birds.* Some birds wait for their prey to come within striking distance, others are on the constant search. The movement of an object quickly catches the attention of an observer. Similarly an observer changing his position brings out relative position, perspective, and recognition of objects. Thus some birds, pressed by necessity, have developed in the extreme the habit of rapidly changing position, peering in many directions, to secure food required for existence.

The paper was discussed by Drs. LYON and BARTSCH.

T. S. PALMER: *Notes on some parrots imported into the United States.* Of the 500 or more species of parrots now known, only 2 are natives of the United States and none of Europe. Thus they were practically unknown to the ancients. The knowledge of parrots is, therefore, an index to exploring activity. Columbus took the first American parrot to Spain in 1493. The first importation was at an early, though unknown date. Since then the United States has become one of the best parrot markets. The zoological parks contain the best collections, and have rare and some now extinct parrots on exhibition. The national Zoological Park has about 35 species. At times 75 or 80 species have been on exhibit at one time in New York and Philadelphia. The London Zoological Gardens have about 125 species.

The parrots imported in largest numbers are: the Amazons; certain species from Mexico and from Cuba; the Grass Parrakeet from Australia; and the Gray Parrot from Africa. The Amazons and the Gray Parrots are popular on account of their ability to talk. In 1904 more than 17,000 parrots were imported. This year more than 4,000 have already (April) reached San Francisco.

Few parrots are raised in this country though in Europe they are quite freely raised in captivity. The habits of parrots, and even their anatomy, are still not well known. Probably a dozen West Indian parrots have become extinct, and our Carolinian Parrakeet is confined to Florida and is almost extinct. The desirability of immediate further study is obvious.

E. A. GOLDMAN: *Rats in the War Zone.* Rats infested the whole war area, and their relation to epidemic diseases was early recognized. The speaker was commissioned as an officer to study and solve the problems presented by rats. Their holes, burrows, and paths were everywhere. German trenches were infested and many rat-catching devices were found in them. Rats were troublesome in disturbing sleeping soldiers, destroying supplies, eating and spoiling food, and as potential carriers and disseminators of disease.

Food was arriving in greater quantities that it could be cared for. Under the boards or litter upon which the cases of food were stacked, rats found shelter and opportunity to breed. Trapping was the chief means for control, but poisoning with squills was also effective. In food warehouses and trenches the control was reasonably adequate.

Rats bred rapidly. Females averaged 7.3 embryos. The number was as few as 3 and as great as 17. The principal species was the brown rat. Black rats were sometimes found where there were few brown rats to contend with. After the trenches were evacuated, foxes, weasels, cats and other predatory animals did much to eliminate rats, but many followed the men.

Many lantern slides were shown depicting the conditions which favored rats, their work, the methods of trapping, and some of the means of insulating against rats, both in the Allied and German lines.

A. A. DOOLITTLE, *Recording Secretary.*

BOTANICAL SOCIETY

153RD MEETING

The 153rd meeting was held in the Assembly Hall of the Cosmos Club at 8 p.m., October 4, 1921, with President CHAMBLISS in the chair and 106 persons present.

A. T. BRUMAN and FRANK G. O'DONNELL of the Federal Horticultural Board and ROBERT C. WRIGHT of the Office of Horticulture and Pomology were elected members of the Society.

An exhibit of dahlias was furnished by Mrs. WOLF, Dr. W. A. ORTON, Prof. J. B. S. NORTON, Dr. WM. E. SAFFORD and Miss FLORENCE THOMPSON. The regular program of the evening, consisting of a symposium on the dahlia, followed.

W. A. ORTON: *Group classification, climatic requirements and aims of dahlia breeders.*

The dahlia has been wonderfully improved by plant breeders until its range of form suggests the anemone, the water lily, the peony, the rose, and the chrysanthemum, as well as the types familiar to the public as dahlias.

Of the distinct groups of dahlias, the oldest is the Show. Then there are the Hybrid Show, Pompon, Fancy, Cactus, Hybrid Cactus, Decorative, Peony Duplex, Single, Collarette, Anemone, Star and Miniature Cactus.

The dahlia, a native of the tropics, can not withstand our northern winters. The roots must therefore be lifted and stored in sand in a cool cellar.

Those who are working for the further improvement of the Dahlia have still a large field of effort. In all cases, and particularly in the Cactus types, there is need for stronger, more upright stems, for greater freedom of flowering, and quality of producing strong, hardy roots. Some of the best varieties are such poor propagators that they always remain scarce and expensive.

J. B. S. NORTON: *History of the dahlia varieties.*

A tabulation of over 100 dahlia catalogues of 1921 shows about 5000 varieties now on the market. Nearly 5000 other named varieties grown in years past have now disappeared from cultivation. All these have developed in the gardens of Europe and America since the wild single dahlia was introduced from Mexico into European gardens a little over a hundred years ago.

The old-fashioned ball-shaped, regular forms, or show dahlias, were the first double kinds developed and had their day in the great dahlia shows of the second quarter of the nineteenth century. The minature ball forms, or pompons came in in the fifties. Some of them are probably the oldest varieties now in our gardens. The advent of the cactus dahlia type in 1873 led, through hybridization with the earlier kinds, to the many kinds of cactus, decorative and peony flowered dahlias which grace our gardens at the present time. The show dahlias, so desirable in the formal days of 1830 to 1850, have now almost disappeared from prize collections. Even the graceful cactus varieties which were the fashion at the beginning of the twentieth century are now far out-numbered by the great gloriously colored decoratives and hybrid cactus kinds which are now being produced more than any other types, especially in America.

W. E. SAFFORD: *Botany and chemistry of the dahlia* (illustrated).

In tracing the origin of the cultivated plants, it has been the custom to go back to the very earliest descriptions, noting the dates when they were written as well as those of their publication. Among early writers the rules of nomenclature now followed by botanists were not always observed. It was not uncommon for a botanist to ignore a well-established generic or specific name and substitute another more in accord with his own taste. Thus in 1809 Willdenow attempted to substitute Georgina for the generic name Dahlia established by the Spanish botanist Cavanilles in 1791 in honor of Andreas Dahl, a distinguished Swedish horticulturist, and finding the seedlings of the type of the genus to be exceedingly variable, he also changed its specific name, *pinnata* to *variabilis*. The variability points to a mixed ancestry, and it is quite possible that Cavanilles' type plant was a hybrid between two species or two distinct varieties or subspecies.

About the year 1576, more than two hundred years before the genus Dahlia was established by Cavanilles, Francisco Hernandez, a Spanish physician, sent by Philip II to New Spain to study its resources, observed many forms of Dahlias then cultivated in Mexico. It is interesting to note that at that early date types which are usually held to be modern creations, had already been developed. Dahlias were known to the Aztecs under the Nahuatl name *Acocoxochitl*, which may be translated "Cane-flower." This name was applied to them on account of their hollow, jointed stems, which bear a certain resemblance to the canes used as water pipes or tubes. Hernandez in calling attention to their beautiful and varied flowers, described certain forms with purple rays and yellow disks, and many others differing from one another in size and color; some white, others yellow, others red or purple, or white tinged with purple, or perhaps yellow tinged with red, and a great

many other kinds; in some cases with double or multiple whorls of ray flowers about the disk, or with the florets closely crowded into compact pompons or bunches (*Manipuli*). The roots he described as fleshy and succulent, and clustered like those of the classic asphodel. This description, although written about 1576, was first published in the Madrid edition of his works in 1750. In the Roman edition of 1790, however, are figured three forms of Dahlia, all of them with multiple florets suggesting forms now called the peony type, but differing in their foliage, the first two having leaves like those commonly called *Dahlia variabilis*, the last with divided leaves like those of *Dahlia glabrata*, or *D. gracilis*.

Four years later in addition to *Dahlia pinnata*, Cavanilles described and figured two other species, *Dahlia coccinea* and *Dahlia rosea*, "single flowered" forms differing from each other not only in color but also in the form and texture of the leaves. Some writers declare that these were merely two varieties of the same species, while others deny the possibility of this, declaring that *D. coccinea* and *D. rosea* cannot even be cross-pollinated to form hybrids.

The great revolution in Dahlia culture which led to the creation of the beautiful forms of today was brought about by the importation of *Dahlia juarezii* into Europe about the year 1864, a type of which is here presented, accompanied by a photograph of the well-known "Kalif" of our gardens, which seems to be a facsimile of it. *Dahlia juarezii* is the ancestor of all our cactus dahlias. It is interesting to note that the type of this species like that of *Dahlia pinnata*, was a "double form" and in all probability a hybrid. Recently, Mr. Wilson Popenoe, an explorer for the United States Department of Agriculture, came upon a single red Dahlia in the mountains of Guatemala with narrow rays reflexed or folded backward as in *Dahlia juarezii* and its descendents. This species, which I named *Dahlia popenovii* in honor of its collector, is in all probability the ancestor which gave to *Dahlia juarezii* and to all the cactus dahlias their tendency to fold back the margins of their florets.

On the same slide is shown *Dahlia maxonii*, another species from Guatemala, collected by Mr. William R. Maxon in the Department of Alta Verapaz in 1905. The latter species was for a time confused with *Dahlia imperialis*, from which it differs radically in its upright instead of pendent flowers, as well as in the form of its leaves. It is in all probability an ancestor of the hybrid *Dahlia excelsa*, the type of which was a cultivated plant with abnormally elongated disk-flowers resembling the so-called anemone-flowered types of our gardens.

Concerning the roots of the Dahlia, these were compared by early writers with those of the asphodel, which were also fleshy and grew in clusters. Attempts have been made to use the roots for food for cattle and pigs, but on account of the unpleasant taste they have been rejected. Instead of starch the roots contain a substance known chemically as inulin. From this a sugar known as levulose or fructose is obtained. This sugar is sixty per cent sweeter than cane sugar, but it has hitherto commanded such very high prices that it has not been of commerical importance. It crystallizes with great difficulty, and the expense has been chiefly due to the fact that it was necessary to use much alcohol in eliminating the water. Although this sugar crystallizes with difficulty, yet it can be utilized even in the form of syrup, especially at soda fountains, and as an ingredient for various drinks and desserts.

The Regular Meeting then adjourned and the Annual Meeting was held. Dr. W. E. SAFFORD was elected President, Dr. HOMER L. SHANTZ was elected Vice-President, Mr. ROY G. PIERCE was re-elected Recording Secretary, Mr. R. K. BEATTIE was re-elected Corresponding Secretary, and Dr. L. L. HARTER was re-elected Treasurer.

154TH MEETING

The 154th meeting was held in the Assembly Hall of the Cosmos Club at 8 p.m., November 1, 1921, with President SAFFORD in the chair, and 68 members and guests present. Among the distinguished guests were Professor ARTHUR A. JACZEWSKI, Director of the Institute of Mycology and Plant Pathology of Petrograd, and Prof. NICHOLAS I. VAVILOV, Director of the Institute of Bureau of Applied Botany and Plant Breeding at Petrograd. Mr. JAMES R. WEIR, whose name was presented at the October meeting, was voted into the Society.

Under *Brief notes and review of literature*, Mr. C. P. HARTLEY presented an exhibit of several interesting ears of corn, two with long silks retained and one a nubbin. One was peculiar in that the fine silk retained was attached to the kernels; the second showed that the first silks that protrude do not come from the extreme butt kernels, but from those slightly above the base of the stalk, differing from the popular conception; the third showed that the seed coat can develop without any starch or germ.

O. M. FREEMAN, of the Bureau of Plant Industry, exhibited two potted hepaticas, one in blossom, and the other without blossoms. The plant in blossom has been subjected to an artificial winter. In the experiment 6 pots had been used—3 had been chilled for 2 months, while the others had been kept at ordinary room temperature. Two weeks after being chilled they came into blossom. Prof. ARTHUR A. JACZEWSKI of Petrograd remarked that this chilling of plants to induce flowering was formerly a regular practice in Russia and that lilacs were brought out in blossom at Easter time.

The regular program of the evening consisted of an illustrated lecture by Mr. ROBERT S. YARD, Executive Secretary of the National Parks Association. A wonderful collection of colored views of some of our National Parks was shown, including some from the Yellowstone Glacier, Mount Rainier, Crater Lake, Yosemite, Sequoia and Rock Mountain National Parks. Of the 19 national parks all but 2 are in the United States. These include Mt. McKinley in Alaska and a volcano in Hawaii. Water power and irrigation interests were trying to encroach upon the public domain and to secure special privileges in the National Parks. The National Park Association was trying to crystallize public sentiment against the exploitation of these Parks.

ROY G. PIERCE, *Recording Secretary*.

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MINERALOGY.—*Notes on white chlorites.*[1] EARL V. SHANNON and EDGAR T. WHERRY, U. S. National Museum.

Although the name chlorite comes from the Greek word for green, various other colors are represented among this group of minerals, including violet-red in kaemmererite, and white in leuchtenbergite and other sub-species or varieties. The mineral colerainite, described in 1918 by Poitevin and Graham,[2] is in our opinion a white chlorite, since its composition, crystal form, optical properties, and physical properties are all similar in many respects to those of typical members of the clinochlore group. It seemed of interest to ascertain whether the material reported as colerainite from Brinton's Quarry, Chester County, Pennsylvania, by Mr. Samuel G. Gordon[3] could also be so classified, and Mr. Gordon kindly sent the Museum samples for examination and analysis. Sample 1 is composed of 3 to 5 mm. barrel shaped crystals, bounded by greatly rounded first and second order pyramids and prisms, with large basal planes. These are not solid, but have a dull white crust with loosely packed flaky material with pearly luster within. Under the microscope the material is fairly homogeneous, although some dull, opaque patches are present mingled with the transparent flakes. Specimen 2 is from a new locality discovered by Mr. Gordon, namely a small abandoned feldspar quarry about 2 miles southwest of Nottingham, Chester County, Pa. This is in more micaceous-looking and apparently less altered crystals of similar shape and size. Under the microscope its homogeneity is satisfactory. Similar material occurs also in feldspar quarries near Sylmar, Pa., but it is too altered for analysis; its crystallography is described below.

[1] Presented at the meeting of the Mineralogical Society of America, Dec. 29, 1921. Published by permission of the Secretary of the Smithsonian Institution. Received December 31, 1921.

[2] Canada Dept. Mines, Museum Bull. **27**: 66–73. 1918.

[3] Amer. Min. **5**: 195. 1920.

Another white chlorite of related composition is sheridanite, described from northern Wyoming by J. E. Wolff in 1912.[4] This differs considerably in properties, however, being a translucent greenish gray schistose rock. A specimen of schistose rock from Miles City, Montana, has recently been sent in to the U. S. Geological Survey for identification, and Dr. E. S. Larsen has found it to agree optically with sheridanite. This has also been analyzed, and found to have the same composition as the original sheridanite, so is here reported as a new occurrence of this mineral. In the analyses extreme care was taken to separate the aluminium from the magnesium, the aluminium hydroxide being reprecipitated several times. The results of the new analyses, with older ones for comparison, are presented in table 1.

TABLE 1.—ANALYSES OF WHITE CHLORITES. THE ASTERISKS INDICATE NEW ANALYSES AND OPTICAL DATA. THE NUMBERS IN PARENTHESES AFTER ANALYTICAL DATA ARE RATIOS

	1*	2*	3	4*	5	6
SiO_2	28.10(2)	36.70(6)	28.81(2)	27.78(2)	26.98(3)	24.40(2)
Al_2O_3	26.20(1)	10.38(1)	26.43(1)	24.30(1)	16.10(1)	22.77(1)
Fe_2O_3	1.66	1.22	0.24	1.43	0.22	0.45
FeO	none	trace	0.40	0.35	none	none
CaO	trace	0.86	none	trace	0.12	0.10
MnO	trace	trace	none	none	0.20	0.09
MGO	30.36(3)	36.44(9)	31.21(3)	32.71(3)	36.56(6)	32.70(4)
K_2O	...	...	0.35	...	0.28	0.30
Na_2O	...	...	0.14	...		
H_2O-	0.56	1.06	0.09	0.06		
					19.91(7)	19.63(5)
H_2O+	14.00(3)	13.80(7)	12.62(3)	13.01(3)		
Totals	100.88	100.46	100.29	99.64	100.37	100.44
Opt. data	*	*	...	*	*	...
α	1.562	1.555	1.580	1.576	1.570	...
β	1.562	1.560	1.581	1.576	1.570	1.570
γ	1.576	1.560	1.589	1.589	1.575	...
Sign	+	−	+	+	+	+
2E	0°	30°	35°	small	0°	0°

1. White chlorite from Brinton's Quarry, Pa. Analysis by Shannon; optical data determined on an exceptionally clean cut crystal and kindly furnished by Mr. Gordon.

2. White chlorite from Nottingham, Pa. Analysis by Shannon; optical data by Wherry.

3. Sheridanite, northern Wyoming. Analysis by Wolff, optical data by H. E. Merwin.

4. New occurrence of sheridanite (Wyoming?). Analysis by Shannon; optical data by Larsen.

5. Coleraimite matrix, Quebec. Analysis by Connor quoted by Poitevin and Graham, loc. cit. Optical data by Wherry on specimen kindly furnished by Prof. T. L. Walker.

6. Coleraimite crystals, Quebec. Analysis by Connor; optical data by Poitevin and Graham.

[4] Amer. Jour. Sci. IV, **34**: 475–476. 1912.

As to occurrence and origin, the Pennsylvania specimens are reported by Mr. Gordon to have been formed by the action on albite-pegmatite of magnesium-bearing waters derived from the weathering of serpentine and jefferisite.[5] The original colerainite had a similar origin.[6] The sheridanite occurs in granitic rocks, and may have also arisen through alteration of feldspar, but details of its occurrence are not known.

Both Pennsylvania minerals are rather different from colerainite in composition, but the first one agrees closely with sheridanite in this respect, although entirely different from it in physical properties. It is not possible at present to interpret the analyses of any of these in terms of end-minerals, so it seems best to class them all simply as white chlorites.

A crystallographic confirmation of the identity of these minerals seemed desirable, but the Brinton's Quarry and Nottingham material proved to be too dull on the surface to give definite results. Optical examination of the so-called secondary albite from Sylmar, Pa.[7] showed, however, that it is of similar character although too extensively altered to kaolinite to be suitable for analysis. It occurs in rosettes of subparallel crystal plates on compact albite rock, averaging 5 by 1 mm. in size, with perfect basal cleavage on which the luster is bronzy. These were found to give hazy light nodes as a number of places in each zone of faces, yielding the results shown in table 2.

TABLE 2.—ANGLES OF WHITE CHLORITE FROM SYLMAR, PA.

Crystallization perihexagonal; $c = 3.3890 \pm .0050$

No.	Letter	Symbols Gdt.	Symbols Brav.	Mono	Description	Observed φ	Observed ρ	Calculated φ	Calculated ρ
1	*c*	0	0001	001	Dominant form	..	0°	...	0°00′
2	*b*	∞0	$10\bar{1}0$	{010, 110}	Narrow to fairly broad	0°	89–90°	0°00′	90°00′
3	*m*	10	$10\bar{1}1$	{112, 011}	Narrow but distinct	0°	66–67°	0°00′	66°07′
4	*t*	4/30	$40\bar{4}3$	043	Narrow but distinct	0°	70–71°	0°00′	71″38′
5	*o*	20	$20\bar{2}1$	$\bar{1}11$	Narrow to fairly broad	0°	77–78°	0°00′	77°32′
6	*v*	1	$11\bar{2}1$	{132, $\bar{1}01$}	Rather large	30°	75–76°	30°00′	75°40′
7	*s*	½	$11\bar{2}2$	$\bar{1}34$	Narrow and poor	30°	63–64°	30°00′	62°56′

The identification of the material as a white chlorite is thus complete.

[5] Proc. Acad. Nat. Sci. Phila. **1921**[1]: 169–192. 1921.
[6] Trans. Royal Soc. Canada III, **12**: 37–39. 1918.
[7] Amer. Min. **3**: 47. 1918.

MINERALOGY.—*Crocidolite from eastern Pennsylvania.*[1] EDGAR T. WHERRY and EARL V. SHANNON, U. S. National Museum.

The occurrence of a glaucamphibole in the Highland belt of pre-Cambrian rocks of eastern Pennsylvania was noted by D'Invilliers in 1883.[2] He classed the mineral as an amphibole on the basis of a "rough analysis" by State Chemist McCreath made on "a portion of the mass more or less mixed with feldspar" which yielded, when the meaningless decimals are omitted: SiO_2 51.7, Al_2O_3 17.5, "FeO" (probably at least half Fe_2O_3) 9.2, MgO 8.8, CaO 5.1, and "undetermined" (no doubt $Na_2O + H_2O$) 7.7%. This corresponds more or less to a mixture of labradorite with a high magnesium glaucamphibole. In the absence of optical data, however, the exact identity of the latter could not be established.

Another occurrence of the mineral in the pre-Cambrian was studied by Mrs. Eleonora Bliss Knopf in 1913.[3] She classed the mineral as glaucophane on the basis of an analysis by Dr. Edwin DeBarr, but judging from the silica percentage of 83.3, this was made on a sample containing a large amount of quartz in addition to feldspar, and is accordingly unsuitable for establishing the exact nature of the mineral. Mrs. Knopf obtained in addition some optical measurements agreeing with those recorded for the glaucamphibole group, but not characteristic of any individual member: extinction angle $X/c = 3°$ to 15°, and pleochroism Z blue to violet, Y pale green, and X colorless to pale yellow.

While the senior writer was connected with Lehigh University, Bethlehem, Pa., he observed glaucamphiboles at many localities in the region, in both pre-Cambrian and Triassic rocks. On removal to Washington, he presented a number of specimens to the National Museum, and made a study of their optical properties, by the immersion method. Much of the material proved to be cryptocrystalline, with n = about 1.66 and intense blue color. At some localities, however, microscopically fibrous to bladed material occurs, and this gave alpha = 1.64 to 1.65, beta = 1.65, gamma = 1.66. The pleochroism is X yellow, Y green, Z blue. The double refraction varies from one specimen to another, but is sometimes so low that

[1] Presented at the meeting of the Mineralogical Society of America, December 29, 1921. Published by permission of the Secretary of the Smithsonian Institution. Received Dec. 31, 1921.

[2] Second Geol. Survey Penna. Rept. D 3, II, 1: 93–94. 1883.

[3] Bull. Amer. Mus. Nat. Hist. 32: 517–526. 1913.

anomalous interference colors due to high dispersion in some indeterminate direction are shown. One of the best samples for optical study came from a road metal quarry southwest of the town of Mohnton, Berks County, the rock being a highly metamorphosed Triassic sandstone. Other noteworthy localities in similar rock, as well as in the Triassic diabase causing the alteration, lie three miles—5 kilometers—south of the city of Reading, and just east of Little Oley, south of Boyertown, Berks County. In addition to the pre-Cambrian gneiss occurrences listed by Mrs. Knopf, it is abundant in these rocks north of Oley Line, Berks County, and northeast of Dillingerville, Lehigh County. It also occurs for some miles northeastward from Riegelsville, Pa., in the state of New Jersey. In all perhaps fifty localities are known.[4]

TABLE 1.—ANALYSIS AND RATIOS OF CROCIDOLITE FROM OLEY LINE, PA.

	Analysis	Ratios	Theory
SiO_2	51.62	0.86 or 6	50.7 (6)
Al_2O_3	0.92	0.01	
Fe_2O_3	18.36	0.12 or 1	22.4 (1)
Ti_2O_3	2.27	0.02	
FeO	10.93	0.15 or 1	10.1 (1)
MgO	5.92	0.15	5.6 (1)
CaO	0.48	0.01 or 1	
Na_2O	5.62	0.09 or $^2/_3$	8.7 (1)
K_2O	0.66	0.01	
H_2O^+	2.57	0.14 or $^4/_3$	2.5 (1)
H_2O^-	1.04	0.06	
Sum	100.39		100.0

Becoming interested in the identity of the mineral, the junior author analyzed a sample from the locality north of Oley Line, which was kindly selected and purified by Mr. C. S. Ross of the U. S. Geological Survey, and proved to be cryptocrystalline and homogeneous on microscopic examination. The analysis, the first made on pure material, showed the mineral to be a semimagnesium crocidolite, with the formula $H_2O.Na_2O.MgO.FeO.Fe_2O_3.6SiO_2$.

The high percentage of titanium present suggests that this element, in its lower state of oxidation, may partially account for the extremely intense color of the mineral, although admittedly part of the color is due to iron. Titanium has therefore been regarded as replacing aluminium and iron, rather than silicon. The low content of alkalies

[4] Professor A. H. Phillips reports it also in the highlands of New York State. It is represented in some mineral collections under the name vivianite.

is evidently connected with partial replacement of sodium by hydrogen, total alkalies plus total water amounting to the theoretical ratio of 2. The rôle of water in the glaucamphiboles appears never to have been studied, but as most of the analyses show on the average 2% of this constituent, it is probably at least in large part essential.

It is interesting to consider the mode of occurrence of the material: it is found as impregnations and coatings in gneissoid rocks of pre-Cambrian age, in diabase of Triassic age, and in sediments of the latter age intruded by the diabase. The gneisses thus impregnated are usually greatly shattered; the crocidolite not only fills the resulting crevices, but also replaces the original minerals of the gneiss. Replacement of hornblende was described by Mrs. Knopf, and it may be added that the rocks, which usually contain considerable primary quartz where unaltered, are practically free from this mineral in extensively crocidolitized zones. Some of the silica has been redeposited, with the crocidolite, in the form of secondary quartz. The same phenomenon is noticeable in the replacement of these gneisses by sericite[5] which is of frequent occurrence in the region, namely that the primary quartz is replaced more rapidly than the feldspar. This points to the deposition of the crocidolite, like the sericite, from hydrothermal solutions. The shattering of the crocidolitized gneisses is, in the experience of the senior writer, almost always connected with faulting of late Triassic date, and since the same mineral occurs in the late Triassic diabase and the sediments it has metamorphosed, the suggestion is here made that the hydrothermal solutions which deposited the crocidolite in the various occurrences came alike from the Triassic diabase magma.

PALEONTOLOGY.—*Middle Eocene Foraminifera of the genus* Dictyoconus *from the Republic of Haiti.*[1] WENDELL P. WOODRING, U. S. Geological Survey.

In 1900, Chapman (1, pp. 11–12, pl. 2, figs. 1–3) described as *Patellina egyptiensis* a curious conical species of Foraminifera that was collected in northern Egypt between Cairo and Suez from rocks that were then supposed to be of lower Miocene age. The generic name *Patellina* was used by Chapman as the equivalent of *Orbitolina*. Blanckenhorn (2, pp. 419, 432–435) showed that the rocks from which Chapman's specimens were collected are part of the lower Mokattam group of mid-

[5] WHERRY. Bull. Geol. Soc. Amer. 29: 383. 1918.

[1] Published by permission of the Engineer in Chief, Republic of Haiti, and of the Director, U. S. Geological Survey. Received April 24, 1922.

dle Eocene (Lutetian) age. As *Patellina egyptiensis* is different from the Recent species of *Patellina* and the Cretaceous species of *Orbitolina*, Blanckenhorn proposed for it the new generic name *Dictyoconus*.[2] Blanckenhorn considered *Dictyoconus* a guide genus of the lower "Mokattamstufe." *Dictyoconus egyptiensis* was fully described by Schlumberger and H. Douvillé, 1905 (3, pp. 298–304, pl. 9).

During a geological reconnaissance of the Republic of Haiti in the winter of 1920–1921 by J. S. Brown, W. S. Burbank, and myself, numerous specimens of two new species of *Dictyoconus* were collected from a limestone that crops out in the central and southern parts of the western half of the Département du Nord. The limestone was named by Vaughan (4, pp. 58, 94) the Plaisance limestone. The most abundant species is remarkably similar to *Dictyoconus egyptiensis;* but the other species is even more depressed than the microscope form of *Dictyoconus egyptiensis* figured by Schlumberger and H. Douvillé, and it has an undulate base. These Haitian species will be described in a report on the geology of the Republic of Haiti now being prepared for publication. Thin sections show that they have the same internal structure as the Egyptian specimens.

The structural relations of the Plaisance limestone indicate that it is of middle Eocene (Lutetian) age, and not of upper Eocene (Priabonian) age, as was supposed when it was named. The evidence furnished by the Foraminifera seems to be a striking confirmation of its middle Eocene age. The Plaisance limestone is the first formation of middle Eocene age recognized in the West Indies proper, as the upper Eocene is the only one of the commonly accepted subdivisions of the Eocene heretofore recognized (5, p. 607).

A third species of *Dictyoconus* was collected at many localities in the northern part of the Republic from rocks that are clearly of upper Eocene (Priabonian) age. This species is found with *Orthophragmina crassa* Cushman, *Orthophragmina cubensis* Cushman, and other upper Eocene orbitoidal Foraminifera, and it seems to be similar to *Dictyoconus americana* (Cushman), which was described from the upper Eocene (Priabonian) St. Bartholomew limestone of the island of St. Bartholomew (6, p. 43, text fig. 3). The species described from St. Bartholomew is the only American species that has heretofore been described. Cushman (4, pp. 105, 106) has recorded the same or a similar species from the upper Eocene of the Dominican Republic.

[2] On p. 419 where the genus is first mentioned by Blanckenhorn the spelling is *Dictyoconus*, but on the following pages the less desirable spelling *Dictyoconos* is used.

Similar conical Foraminifera of Eocene age have commonly been called by the generic name *Conulites*, and Chapman in 1902 (**7**, pp. 156–157, 276, pl. 8, figs. K, k, text fig. 36) called the Egyptian species *Conulites aegyptiensis*. The genus *Conulites* was described by Carter in 1861 (**8**, pp. 331–332, 457–458, pl. 15, figs. 7, 7a–g; **9**, pp. 53–54, 83–84) for a species of Foraminifera, apparently of middle Eocene (Kirthar) age, from western India. According to Carter's description and figures the Indian specimens have a different structure from the Egyptian and West Indian specimens. Blanckenhorn (**2**, p. 433) suggested that some of the Foraminifera described by Carter in the same papers as *Orbitolina* are similar to the Egyptian *Dictyoconus*.

In 1904 Prever and Silvestri (**10**, pp. 470, 477–486, figs. 1–5) proposed the new generic name *Chapmania* for *Patellina egyptiensis* on the invalid grounds that *Dictyoconus* was a synonym of *Orbitolina*, and was briefly described and not figured. They described and figured under the name of *Chapmania aegyptiensis* (Chapman) a middle Eocene species of Foraminifera from Italy that has a different structure from the Egyptian and West Indian specimens. Silvestri (**11**) and Airaghi (**12**, p. 160; **13**, pp. 182–185, pl. 5, figs. 1–4) recorded this Italian species from several localities. In view of the differences between the Egyptian and Italian species Silvestri later (**14**, **15**) redescribed the Italian species as *Chapmania gassiensis*.[3]

In 1912 Schubert (**16**) described and figured *Coscinolina liburnica* Stache, a genus and species from basal middle Eocene rocks of the Istrian-Dalmatian coast that had been imperfectly described by Stache in 1875 (**17**). *Coscinolina* has a more pronounced early spiral stage than *Dictyoconus or "Chapmania,"* and was considered by Schubert as a more primitive type. *Coscinolina liburnica* has been recorded by H. Douvillé (**18**, **19**) from northern Egypt in beds below the horizon of *Dictyoconus*.

The available records show that these conical Eocene Foraminifera, *Conulites*, *Dictyoconus*, *Coscinolina*, and the Italian genus called *Chapmania*, are strictly tropical. Their range in latitude is even more limited than the range in latitude of the orbitoidal genera *Orthophragmina* and *Leipdocyclina*, which migrated northward to southwestern France and to the southern Coastal Plain of the United States. The remarkable similarity of the Egyptian and West Indian species of *Dictyoconus* is another example of the striking resemblance of the

[3] As *Chapmania* is a synonym of *Dictyoconus*, the Italian species should receive a new generic name.

West Indian Tertiary faunas to those of the same age in the Mediterranean region.

LIST OF PAPERS CITED

1. CHAPMAN, F. *On a Patellina-limestone and another Foraminiferal limestone from Egypt.* Geol. Mag., new ser., Dec. 4, **7:** 3–17, *pl. 2.* 1900.

2. BLANCKENHORN, MAX. *Neues zur Geologie und Paläontologie Aegyptens.* Deutsche geol. Gesell. Zeitschr. **52:** 403–479. 1900.

3. SCHLUMBERGER, CH., and HENRI DOUVILLÉ. *Sur deux Foraminifères Éocènes.* Soc. géol. France Bull. IV, **5:** 291–304, *pl. 9, 7 text figs.* 1905.

4. VAUGHAN, T. W., WYTHE COOKE, D. D. CONDIT, C. P. ROSS, W. P. WOODRING, and F. C. CALKINS. *A geological reconnaissance of the Dominican Republic.* Dominican Rep. Geol. Surv. Mem. **1.** Pp. 268, *pl. 23.* Washington, 1921.

5. VAUGHAN, T. W. *The biologic character and geologic correlation of the sedimentary formations of Panama in their relation to the geologic history of Central America and the West Indies.* U. S. Nat. Mus. Bull. **103:** 546–612. 1919.

6. CUSHMAN, JOSEPH AUGUSTINE. *Fosil Foraminifera from the West Indies.* Carnegie Inst. Washington Pub. **291:** 23–71, *15 pls., 8 text figs.* 1919.

7. CHAPMAN, FREDERICK. *The Foraminifera, an introduction to the study of the Protozoa.* Pp. XV, 354, *pls. 14, figs. 42.* London, 1902.

8. CARTER, H. J. *Further observations on the structure of Foraminifera, and on the larger fossilized forms of Sinde, etc., including a new genus and species.* Annals and Mag. Nat. Hist. III, **8:** 309–333, 366–382, 446–470. *Pls. 15–17.* 1861.

9. CARTER, H. J. *Further observations on the structure of Foraminifera and on the larger fossilized forms of Sinde, etc., including a new genus and species.* Bombay Branch Roy. Asiatic Soc. Journ. **6**[21]: 31–96. 1862.

10. PREVER, P. L., and A. SILVESTRI. *Contributio allo studio della Orbito-linae.* Soc. geol. Italiana Boll. **32:** 467–486, *figs. 1–5.* 1904.

11. SILVESTRI, A. *Località Toscana del genre* Chapmania *Silv. et Prev.* Boll. del Naturalista **24:** 117–119, *figs. 1–3.* 1904.

12. AIRAGHI, ZINA LEARDI in, *Foraminifera Eocenici di S. Genesio (Collina di Torino).* Soc. Ital. Sci. Nat. Atti **43:** 159–171. 1905.

13. AIRAGHI, ZINA LEARDI in, *Il* Conulites aegyptiensis *Chapman e la* Baculogypsina sphaerulata *(Parker e Jones) di S. Genesio, Foraminiferi Eocenici dei Colli Toriensi.* Soc. Ital. Sci. Nat. Atti **43:** 182–188, *pl. 5.* 1905.

14. SILVESTRI, A. *Sul* Dictyoconus aegyptiensis *(Chapman).* Accad. pontif. nuovi Lincei Atti **58:** 129–131, *fig. 2.* 1905.

15. SILVESTRI, A. *La* Chapmania gassinensis *Silv.* Riv. ital. paleontologia **11:** 113–120, *pl. 2, 2 text figs.* 1905.

16. SCHUBERT, RICHARD. *Über* Lituolella *und* Coskinolina liburnica *Stache sowie deren Beziehungen zu den anderen Dictyconinen.* K.-k. geol. Reichsanstalt Jahrbuch. **62:** 195–208, *pl. 10.* 1912.

17. STACHE, G. *Neue Beobachtungen in den Schichten der liburnischen Stufe.* K.-k. geol. Reichsanstalt Verh. **1875:** 334–338. 1875.

18. DOUVILLÉ, H. *Les Foraminifères de l'Éocène dans la region de Suez.* Soc. géol. France Compt. rend. som. **1920:** 106–107. 1920.

19. DOUVILLÉ, H. *Le gebel Geneffé, d'apres les explorations de M. J. Barthoux.* Soc. géol. France Compt. rend. som. **1921:** 133–135. 1921.

INORGANIC CHEMISTRY.—*The crystal structures of the alkali halides.*[1] II. EUGEN POSNJAK and RALPH W. G. WYCKOFF, Geophysical Laboratory, Carnegie Institution of Washington.

These determinations of the crystal structures of the halides of lithium and the fluorides of the alkali metals have been carried out by the same procedure and with the same apparatus used for part I of this paper.[2] Except for RbF and CsF, determinations of density were at hand for use in finding the number of molecules to be associated with the unit cube. In all cases data will be given for only enough lines to assure the correctness of the chosen structure. In every instance the other lines that appeared gave satisfactory agreement.

LITHIUM FLUORIDE

This salt has already been determined[3] to have the "sodium chloride" structure (fig. 1, part I). According to this previous measurement the length of the side of the unit cube is 4.14 A. U. (or 4.14×10^{-8} cm.).

LITHIUM CHLORIDE

hkl	Estimated intensity	Calculated intensity NaCl grouping	ZnS grouping
111 (1)	10	6,900	10,500
100 (2)	10	7,530	3,700
110 (2)	6	6,640	6,640
113 (1)	4	4,480	6,800

Calculated density = 2.02.
Spacing: d_{100} = 5.17 ± 0.02 A. U.
Structure: NaCl grouping (fig. 1, part I).

LITHIUM BROMIDE

hkl	Estimated intensity	Calculated intensity NaCl grouping	ZnS grouping
111 (1)	10	36,100	43,400
100 (2)	9	27,200	19,300
110 (2)	6	24,000	24,000
113 (1)	4	23,400	28,200

Calculated density = 3.46.
Spacing: d_{100} = 5.48 ± 0.02 A. U.
Structure: NaCl grouping.

[1] Received April 20, 1922.
[2] RALPH W. G. WYCKOFF. This JOURNAL 11: 429. 1921.
[3] P. DEBYE and P. SCHERRER. Phys. Z. 17: 277. 1916.

LITHIUM IODIDE

Considerable difficulty was experienced in preparing anhydrous LiI. The salt which was finally used was fused in an atmosphere of hydrogen and, immediately upon solidification, was powdered and enclosed in a capillary glass tube. A couple of faint lines which were found upon the photographs, but which could not be associated with LiI are undoubtedly due to hydration or decomposition products of this salt. The agreement between the estimated intensities and those calculated from the commonly employed assumptions is not so good as usual.

hkl	Estimated intensity	Calculated intensity NaCl grouping	ZnS grouping
111 (1)	10	88,000	99,200
100 (2)	10	59,100	47,200
110 (2)	6	52,200	52,200
113 (1)	6	57,100	64,500

Calculated density = 3.94.
Spacing: $d_{100} = 6.06 \pm 0.02$ A. U.
Structure: Probably the NaCl grouping.

SODIUM FLUORIDE

hkl	Estimated intensity	Calculated intensity NaCl grouping	ZnS grouping
111 (1)	Absent	141	7,100
100 (2)	10	7,500	75
110 (2)	8	6,650	6,650
111 (2)	3	2,750	27
100 (4)	2	1,480	1,480
120 (2)	4	4,520	45

Calculated density = 2.78.
Spacing: $d_{100} = 4.61_5 \pm 0.01$ A. U.
Structure: NaCl grouping.

POTASSIUM FLUORIDE

hkl	Estimated intensity	Calculated intensity NaCl grouping	ZnS grouping
100 (2)	10	15,100	1,890
110 (2)	9	13,300	13,300
111 (2)	2	5,500	676
120 (2)	4	9,030	1,160
112 (2)	3	7,340	7,340

Calculated density = 2.48.
Spacing: $d_{100} = 5.36 \pm 0.01$ A.U.
Structure: NaCl grouping.

RUBIDIUM FLUORIDE

The diffraction effects observed upon photographs from four different preparations of RbF were essentially the same. They are,

however, so difficult to reconcile with any simple structure for this salt that further work will be necessary to establish its structure with certainty.

CAESIUM FLUORIDE

The density of this salt, as approximately determined from a measurement of its refractive index[4] indicates that four molecules are to be associated with the unit cube. The diffraction data are in such good agreement with a structure containing this number of molecules in the unit that there is little reason for doubting the correctness of the structure here assigned (which is different from that of all of the other caesium halides).

hkl	Estimated intensity	Calculated intensity NaCl grouping	Calculated intensity ZnS grouping
111 (1)	10	74,600	109,200
100 (2)	10	77,200	40,000
110 (2)	7	68,200	68,200
113 (1)	6	48,500	70,800
100 (4)	1	15,200	15,200
120 (2)	3	46,300	24,000
112 (2)	2	37,600	37,600

Calculated density = 4.52.
Spacing: $d_{100} = 6.03 \pm 0.02$ A. U.
Structure: NaCl grouping.

Discussion of these structures.—The data concerning (1) the structures, (2) the dimensions of the unit cells, and (3) the distance of nearest approach of unlike atoms in each crystal of this series are collected in table 1.[5]

On the basis of the available crystal structure data, volumes of "spheres of influence" have been assigned[6] to various atoms and crystals imagined as resulting from a close packing of these atomic spheres. The extent to which these measurements are in agreement with such an hypothesis may be tested by assigning to some one atom an indefinite radius a and obtaining the radii of the other atoms in terms of a. If this is done the calculated distances R–X of table

[4] We wish to thank Dr. H. E. Merwin of this Laboratory for determining the refractive index of caesium fluoride, and suggesting the estimation of its density therefrom. The index is 1.478 ± 0.005. Applying Gladstone's law and using the specific refractive energies given by E. S. Larsen (U. S. Geol. Survey Bull. 679: 31), the density of caesium fluoride is found to be approximately 4.38.

[5] After completing our determinations of the structures of the alkali halides we have become aware of previous work upon some of them through a paper by A. W. HULL. Journ. Frankl. Inst., 193, 217. 1922.

[6] W. L. BRAGG. Phil. Mag. VI, 40: 169. 1920.

1, which are in excellent agreement with the observed distances, are the result. An hypothesis of constant atomic dimensions in crystals which is based on the most reliable data meets, however, with such serious difficulties when passing from compounds of one type to those of another that it can scarcely now be said what significance attaches to such numerical agreements as this one.

TABLE 1.—SUMMARIZED DATA ON THE ALKALI HALIDES

Crystal	Structure	d_{100} A. U.	Distance R–X Observed A. U.	Distance R–X Calculated A. U.
LiF	NaCl (Fig. 1)	4.14	2.07	2.08
LiCl	NaCl (Fig. 1)	5.17	2.58^5	(2.58^5)
LiBr	NaCl (Fig. 1)	5.48	2.74	2.74^5
LiI	NaCl (Fig. 1)	6.06	3.03	3.01
NaF	NaCl (Fig. 1)	4.62	2.31	(2.31)
NaCl	NaCl (Fig. 1)	5.62^8	2.81^4	(2.81^4)
NaBr	NaCl (Fig. 1)	5.95	2.97^5	(2.97^5)
NaI	NaCl (Fig. 1)	6.47	3.23^5	(3.23^5)
KF	NaCl (Fig. 1)	5.36	2.68	2.63
KCl	NaCl (Fig. 1)	6.26	3.13	(3.13)
KBr	NaCl (Fig. 1)	6.59	3.29^5	3.29
KI	NaCl (Fig. 1)	7.11	3.55^5	3.55
RbF	......	..	..	...
RbCl	NaCl (Fig. 1)	6.60	3.30	(3.30)
RbBr	NaCl (Fig. 1)	6.93	3.46^5	3.46
RbI	NaCl (Fig. 1)	7.36	3.68	3.72
CsF	NaCl (Fig. 1)	6.03	3.01^5	3.06
CsCl	Body-centered (Fig. 2)	4.12	3.56	(3.56)
CsBr	Body-centered (Fig. 2)	4.30	3.73	3.72
CsI	Body-centered (Fig. 2)	4.55	3.94	3.98

Note: The distances in parentheses are used to calculate the values in the last column.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY OF WASHINGTON

629TH MEETING

The 629th meeting of the Biological Society of Washington, was held jointly with Washington Academy of Sciences and the Botanical Society of Washington on November 12, 1921 in the Lecture Hall of the Cosmos Club at 8:00 o'clock under the Presidency of the Academy.

Prof. ARTHUR DE JACZEWSKI, Director of the Institute of Mycology and Pathology at Petrograd, delivered an address on *The development of mycology and pathology in Russia.*

Prof. NICOLAS I. VAVILOV, Director of the Bureau of Applied Botany and

Plant Breeding at Petrograd delivered an address on *Russian work in genetics and plant breeding.*

Dr. VERNON L. KELLOGG, Permanent Secretary of the National Research Council, lead a discussion on *The interrelations of Russia and American scientists.*

630TH MEETING

The 630th meeting was held in the Lecture Hall of the Cosmos Club November 26, 1921. President HOLLISTER presided and 44 members were present. Upon recommendation of the Council Mr. THOS. E. PENARD and Dr. T. VAN HYNING were elected to membership. The program was as follows:

R. W. SHUFELDT: *Changes in the skull of an American badger* (Taxidea americana) *due to extreme old age* (illustrated). A reading of Dr. Coues' descriptions of badger skulls, evidently based upon small and imperfect ones, led to an examination of the series in the National Museum. It was found that as distinguished from skulls of young animals, the skulls in older specimens showed a large median crest, with other cranial developments such as greatly developed and outwardly curved zygomas, and a great contraction or pinching of the cranium. These changes in the skull are correlated with the development of the masseter muscles as the specimen grows older.

J. W. GIDLEY: *The* Primates *of the Paleocene.* Information regarding the origin of the Primates is of special interest to man because it is the order to which he belongs, as well as the living lemurs, apes, and monkeys. Fossil primate material is rare and generally fragmentary, and the discussions and conclusions upon the early life history and development of the Primates are necessarily incomplete.

Primates have long been known from the Eocene, but older forms have been found in the Fort Union formation which is Paleocene. In the Eocene of America, two distinct groups of Primates have been recognized, each with several genera and species. One of these, as shown by Matthew, is a subfamily of *Tarsiidae*, and includes at least five groups of supergeneric rank. The other Eocene group, as shown by Gregory, is a subfamily of the European Eocene family *Adapidae* (*Notharctidae*).

Regarding the relationships of the Eocene Primates and especially the Adapidae to the living groups of Primates, there exists among authorities considerable difference of opinion. But there has been a rather generally accepted view that these early Primates were, at least, representative of, if not ancestral to all, or nearly all, of the living lemurs, apes and monkeys. Gregory attempts to show from the lemur-like characters in the Notharctid group, that they are true primitive lemurs, comprising a group of Primates "which is at once the oldest and most primitive which is known from adequate material," establishing an early skeletal type "relatively near to the base of the order, and representing in many respects the earliest ancestors of the higher Primates." Also Gregory describes a hypothetical Paleocene group ancestral to both the *Tarsiidae* and Adapidae (Notharchidae) of the Eocene.

Mr. Gidley stated that his researches in the Paleocene faunas from the Fort Union collection in the National Museum reveals four groups of supergeneric importance: two of them represent new subgroups of the Tarsiidae as defined by Matthew, one is referable to one of Matthew's Eocene subgroups, and the fourth represents the genus *Nothodectus*, described by Matthew and referred by him to a new family, the Nothodectidae. No species was found fulfilling the requirements of a near relative of the Notharctidae, or the hy-

pothetical Paleocene group. Hence Dr. Gregory's contention regarding the evolutionary status of the Notharctid group is not well founded. This conclusion Gidley has substantiated by a restudy of the Eocene Primates, and finds that the Notharctids could not have given rise to any modern lemurs, and because of their advanced stage of development cannot be considered a close connecting link between the Primates and the Insectivores as advanced by Gregory. Mr. Gidley, on the other hand, concludes that since the subfamily groups of the Eocene, which were represented in the Paleocene, are found to be almost as clearly marked in their special lines of development, the origin of these groups is still more remote and the order of Primates and its families have been established longer than has generally been conceded.

Mr. Gidley's paper was discussed by Dr. T. S. PALMER.

J. M. ALDRICH: *An entomologist in Alaska* (illustrated). The speaker visited Alaska last summer for the purpose of making a collection of insects of the interior for the National Museum. He went by steamer to Seward, then up the new government railroad to Fairbanks, and returned the same way. At the time of his visit there was an unfinished portion of the railroad of some 80 miles; he rode a horse across this, but it has since been practically completed. Economic conditions in the interior of the territory he described as very bad on account of the abandonment of gold mining in the last few years. It was hoped that the completion of the railroad would reduce operating costs enough to warrant a resumption of mining, upon which all other activities of the interior depend.

Alaska as far as seen by the speaker is almost wholly forested but the timber away from the coast is thin and small. The rainfall is very heavy along the extreme coast, but behind the first ranges it is much less, and over the main expanse of territory it is about ten or eleven inches; even at the coast north of the Aleutian peninsula it is very light. Agriculture however has been begun in some sections. Crops grow best in the interior, on account of the hotter summers; the region of Fairbanks has considerable possibilities if a population were there to consume the farm products. Lack of market at present makes the business impracticable.

Entomologically the abundance of mosquitoes is one of the chief features. These insects make life a burden during their season, June and July, necessitating various adaptations for protection on the part of the human species. Horseflies and several other kinds of blood-sucking flies are abundant at times or in particular regions. The relations of the fauna are with the Canadian zone of the northern part of the United States and the higher Rocky Mountains in the States; another element follows the Pacific ocean southward along Puget Sound and the coast of Washington and Oregon; no doubt other elements extend to Greenland and westward across Siberia, but these are almost wholly unknown.

Lantern slides were shown illustrating the vegetation, islands, mountains and glaciers, as well as the new railroad to the interior.

Dr. HADWINN, of the Biological Survey, was introduced by Dr. L. O. HOWARD. Dr. HADWINN campared the region discussed with the tundra region in which his collecting was done.

631ST MEETING (42ND ANNUAL MEETING)

The 631st regular meeting and the 42nd annual meeting of the Biological Society of Washington was held at the Cosmos Club, December 10, 1921.

President HOLLISTER called the meeting to order at 8:15 o'clock, with 21 persons present.

Reports were received from the Recording Secretary, Corresponding Secretary, and Committee on Publications. The report of the Treasurer was read, and upon the hearing of the Auditing Committee, consisting of Messrs. OBERHOLSER, HOWELL, and GOLDMAN, was accepted. A Committee of the Council, appointed to draft a memorial to the late WILLIAM PALMER, presented the memorial, which was ordered inserted in the minutes. The Committee consisted of Drs. J. N. ROSE, CHAS. W. RICHMOND, PAUL BARTSCH, and HARRY C. OBERHOLSER. The Corresponding Secretary announced the death of Mr. S. S. VOORHEES.

The balloting for officers of the Society and Members of the Council resulted as follows: *President*, VERNON BAILEY; *Vice Presidents*, A. S. HITCHCOCK, J. W. GIDLEY, S. A. ROHWER, HARRY C. OBERHOLSER; *Recording Secretary*, J. M. ALDRICH; *Corresponding Secretary*, T. E. SNYDER; *Treasurer*, FREDERICK C. LINCOLN. *Members of the Council*, E. A. GOLDMAN, H. H. T. JACKSON, R. E. COKER, R. W. WILLIAMS, W. R. MAXON.

Dr. HOPKINS moved the nomination of VERNON BAILEY as one of the Vice Presidents of the Washington Academy of Sciences.

Dr. PALMER moved that the joint meeting of the Society of Nov. 12, 1921, be included in the series of regular meetings, and that the proper consecutive number be resumed in January; carried.

During the intervals of the balloting the following brief notes were given: Prof. C. V. PIPER: *Note upon Panicum kuntzii.* This grass, otherwise rare, is abundant in a wide region in Florida. It seems not to have been recognized because it rarely blooms. It is locally known as "cut-throat grass" because it occurs in channels called "cut-throats." Cattle eating the grass become salt sick.

Dr. L. O. HOWARD suggested that since the Society is one of the few remaining strongholds of the old fashioned natural history, that a program be arranged in which the old and new view-points can be discussed. Prof. PIPER stated that the broader point of view is emphasized in Shull, Larue, and Ruthven's *Principles of animal biology.* Dr. Howard added Needham's *General biology, and* Cockerell's *Zoology.* Mr. DOOLITTLE said that the death of JOHN BURROUGHS has given impetus to the organizing of nature clubs in the public schools.

Mr. F. C. LINCOLN mentioned the peculiar feeding habits in North Dakota of the sharp-tailed grouse, eating service berries, and buds and flowers of the rosinweed. Prof. PIPER and Mr. GOLDMAN commented upon the great increase of the Hungarian partridge in the Palouse country and elsewhere in Washington. Dr. PALMER added that the birds were introduced in 1914.

A. A. DOOLITTLE, *Recording Secretary.*

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BOTANY.—*New Passifloras from Mexico and Central America.*[1] E. P. KILLIP, National Museum. (Communicated by William R. Maxon.)

For some time past the writer has been engaged in a study of the tropical North American species of *Passiflora*, with particular reference to Mexico and Central America, a region from which few species have been described since Master's comprehensive revision of the American species in 1872. Since the publication of final results is unavoidably delayed, it seems advisable to publish in advance descriptions of certain of the new species, in order that the names may be available.

Passiflora (*Cieca*) **apetala** Killip, sp. nov.

Glabrous throughout; stem angulate, grooved; tendrils solitary; stipules setaceous, 2 to 4 mm. long; petioles 1.5 to 3 cm. long, glandless; leaves broadly cuneate in outline, 3 to 7 cm. long, 2 to 6 cm. broad, bilobate (lobes subapproximate, one-half to quite as long as the undivided portion of blade, obtuse, mucronate), at base subrotund or cuneate, membranaceous, strongly 3-nerved; peduncles in pairs, slender, 2 cm. long; bracts setaceous, deciduous, 2 to 3 mm. long; flowers small, 1.2 to 1.8 cm. wide; sepals oblanceolate, 6 mm. long, 2.5 mm. broad, yellowish green, inconspicuously nerved; petals none; filaments of faucial corona in a single series, filiform, 2.5 mm. long; middle corona membranaceous, plicate, strongly incurved about base of gynophore; basal corona annular; gynophore slender, glabrous, 3 mm. high; filaments capillary, 2 mm. long, the anthers ovate, 1.5 mm. long; ovary depressed-globose, 1 mm. in diameter, glabrous; styles 2.5 mm. long, filiform, the stigmas semiorbicular; fruit black, globose, 8 to 10 mm. in diameter; seeds broadly ovate, 2.5 mm. long, 2 mm. broad, transversely rugose with 6 or 7 nearly parallel ridges.

Type in the U. S. National Herbarium, no. 358,766, collected on Mount Irazú, Costa Rica, altitude 1,000 meters, December 11, 1898, by H. Pittier (no. 13,043); distributed as *P. dicthophylla*.

The foliage of this plant resembles that of certain species of the section *Decaloba* with bilobate leaves, notable *Passiflora ornithoura*, and is unlike that of most of its apetalous allies. From *Passiflora ornithoura* it is dis-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received May 3, 1922.

tinguished not only by the absence of petals but by its longer and narrower sepals and the longer, filiform threads of its faucial corona.

Passiflora arida (Mast. & Rose) Killip.

Passiflora foetida arida Mast. & Rose, Contr. U. S. Nat. Herb. **5**: 182. 1899.

Recent collections from Lower California and northwestern Mexico indicate that this plant is sufficiently distinct from *Passiflora foetida* to deserve specific rank.

Passiflora (*Dysosmia*) **fruticosa** Killip, sp. nov.

Low shrub with an erect caudex, 20 to 40 cm. high, and a few short, sprawling branches; branches and tendrils densely white-lanate; stipules semiannular about the stem, deeply cleft into filiform, gland-tipped divisions; petioles 5 to 15 mm. long, densely lanate, destitute of true petiolar glands but bearing numerous gland-tipped hairs; leaves orbicular in outline, usually 1.5 to 2 cm. long and broad, rarely up to 3.5 cm., 3-lobed (lobes subequal, rounded), at base cordate, 3 to 5-nerved, densely glandular-ciliate, lanate with soft, white to dark brown wool, glutinous; peduncles 1 to 2.5 cm. long; bracts 2- or 3-pinnatisect, hirsute, copiously covered with gland-tipped hairs; flowers 2.5 to 3 cm. in diameter; sepals ovate-lanceolate, 1 to 1.3 cm long, 0.6 cm. broad at base, densely velvety-pubescent without, glabrous within; petals 5 to 7 mm. long, 4 mm. broad, obovate, glabrous; filaments of faucial corona in several series, the outer two or three about 1 cm. long, filamentous, the succeeding series minute, capillary, 1.5 to 2 mm. long; middle corona membranous, not folded, the apex minutely denticulate; basal corona membranous, 1.5 mm. high, the margin entire, recurved; ovary subglobose, silky-pubescent; fruit globose, 2.5 cm. in diameter, densely pubescent with long, silky hairs; seeds oblong, minutely 3-toothed at the apex, truncate at the base, flattened, 5 mm. long, 2.5 mm. broad, reticulate with about 25 meshes to each face.

Type in the U. S. National Herbarium, no. 638,347, collected at Santa María Bay, Lower California, March 19, 1911, by J. N. Rose (no. 16,285).

In addition to the type, specimens from Espiritu Santo, Magdalena Island, and San Francisco Island have been examined. Its shrubby aspect and extreme oiliness, resulting from numerous gland-tipped hairs, distinguish this species from *Passiflora arida*, while its smaller flowers, its proportionately broader petals, and longer faucial corona threads differentiate it from *P. palmeri*.

Passiflora (*Plectostemma*) **cookii** Killip, sp. nov.

Glabrous throughout; stem terete, striate, glaucous; stipules reniform, 1.5 cm. long, 3 cm. broad, glaucous, crenate; petioles 3 to 4 cm. long, glandless; leaves broadly ovate, 8 cm. long, 6 to 7 cm. broad, very obscurely 3-lobed (middle lobe deltoid, obtuse, mucronulate), at base truncate, dark green above, glaucous beneath, peltate about 1.2 cm. from base, quintuplinerved; peduncles about 8 cm. long; bracts not seen; flowers white, 3.5 to 4.5 cm. wide; sepals ovate-lanceolate, 1.5 cm. long, 1 to 1.2 cm. broad, obtuse; petals ovate-lanceolate, abruptly narrowed at the base, obtuse, 1.5 cm. long, 0.8 cm. broad, white, spotted with red; filaments of faucial corona in 2 series, those of the outer series 1 cm. long, dilated at the apex, those of

the inner barely 3 mm. in length, capitate; middle corona membranous, plicate, the apex incurved, fimbrillate; basal corona annular; gynophore 1 cm. high; filaments linear, 6 mm. long, 1.6 mm. wide, white, spotted with red; anthers oblong, 5 mm. long, 2.5 mm. broad; ovary subglobose; styles filiform, 4 mm. long; stigmas reniform, 1 mm. in diameter.

Type in the U. S. National Herbarium, no. 408,302, collected near Finca Sepacuité, Alta Verapaz, Guatemala, April 13, 1902, by O. F. Cook and R. F. Griggs (no. 593).

But one specimen of this species has been examined and upon this no bracts were present. In other respects it bears a strong resemblance to *P. hahnii* and it is to be suspected that it has foliaceous deciduous bracts. It may be distinguished from *P. hahnii* by its larger, crenate stipules, the glaucous under surface of the leaves, and its smaller flowers. From *P. membranacea*, another species of this group, it differs in its spreading sepals and petals, its shorter peduncles, and in the elongate middle lobe of its leaves.

Passiflora (*Plectostemma*) **costaricensis** Killip, sp. nov.

Stem angulate, hirsute with long, spreading, light-brown hairs, glabrescent below; stipules subulate, 6 to 8 mm. long; petioles 1.5 to 2 cm. long, densely hirsute, glandless; leaves oval or suborbicular-oval in outline, 9 to 13 cm. long, 7 to 11 cm. broad, 2-lobed (lobes deltoid, acute or acuminate, mucronate, extending about one-third the length of blade, subapproximate, the terminal sinus nearly semicircular), at base rounded, 3-nerved, membranous, hirsute, especially beneath; peduncles solitary, 1.5 cm. long, articulate at the middle, sparingly pilose; bracts none; flowers 4.5 to 5 cm. wide; sepals linear-lanceolate, 2 cm. long, 0.4 cm. broad, obtuse, hirsute without, glabrous within, the central portion dark green, the margin hyaline, white; petals linear-oblong, 8 mm. long, 2 mm. broad, obtuse, hyaline; filaments of faucial corona in a single series, narrowly ligulate, as long as the petals; middle corona closely plicate, the margin incurved; basal corona annular; ovary minutely puberulent; fruit ellipsoidal, 7 to 8 cm. long, 1 to 1.5 cm. in diameter at the middle, long-tapering at both ends; seeds slightly flattened, narrowly oblong, 3 mm. long, 1.5 mm. broad, black, shining, transversely rugose with 6 or 7 ridges, the ridges smooth, parallel, the axis curved, the beak 0.9 mm. long, recurved.

Type in the U. S. National Herbarium, no. 941,592, collected in the forests of Xirores, Talamanca, Costa Rica, February, 1895, by A. Tonduz (no. 9327).

ADDITIONAL SPECIMENS EXAMINED:

GUATEMALA: Cubilquitz, Alta Verapaz, alt. 350 meters, September, 1901, *von Tuerckheim* (J. D. Smith, no. 7877).

COSTA RICA: Las Vueltas, Tucurrique, January, 1899, *Tonduz* 13,146. Between La Junta and Florida, July 11, 1920, *Rowlee & Stork* 619. Livingston, on Río Reventazon, July 11, 1920, *Rowlee & Stork* 723.

This species is to be distinguished from *Passiflora capsularis* by the shape of the leaves and the character of the faucial corona. In *P. costaricensis* the leaves are longer than broad and are rounded at the base; they have a semicircular sinus, formed by relatively approximate lobes. In *P. capsu-*

laris the leaves are broader than long and are cordate at the base; they have an irregular sinus, formed by widely divergent lobes and a more or less prominent intermediate lobe. The faucial corona filaments are 2-ranked in *P. costaricensis* and 1-ranked in *P. capsularis*.

Passiflora (*Plectostemma*) **heydei** Killip, sp. nov.

Stem obscurely 4-angled, grooved, glabrate below, sparingly hispidulous above; tendrils solitary, glabrate or hispidulous; stipules in pairs, oblong-falcate, 6 mm. long, 3 mm. broad, long-cuspidate, minutely hispidulous, sparsely ciliate; petioles 2 to 5 cm. long, flattened, hispidulous, biglandular, the glands borne within 1 cm. of the apex, clavate, 1.5 mm. long, 0.8 to 1 mm. in diameter; leaves suborbicular-ovate or deltoid in outline, 5 to 8 cm. long, 6 to 10 cm. broad, 3-lobed to slightly below the middle (lobes acute, the central one ovate or ovate-lanceolate, narrowed or frequently broadest at the base, the lateral divergent at an angle of about 70° from the midrib), deeply cordate at base, 3-nerved, repandly dentate or denticulate with mucronulate teeth, membranous, dark green and hispidulous with minute hooked hairs above, paler and densely soft-pubescent beneath; penduncles in pairs, densely hispidulous, 1.5 to 2 cm. long, spreading at right angles; bracts 3, setaceous, 2.5 to 3 mm. long, borne about 1 cm. below the base of the flower, approximate or the uppermost slightly remote; flowers about 2 cm. wide; sepals linear-oblong, 1 to 1.3 cm. long, 3 mm. broad, obtuse, densely hispid and green outside, inside glabrous, white, mottled with red, the apex terminating in a horn about 3.5 mm. long; petals linear-lanceolate, 7 mm. long, 2 mm. broad, obtuse, white (?); filaments of faucial corona in a single series, capillary, 5 to 6 mm. long; middle corona membranous, plicate, the margin slightly incurved, crenulate; secondary middle corona annular, midway between the preceding and the base of the gynophore; basal corona arising at the base of the gynophore, membranous, adnate to the floor of the tube, at length free, 2 mm. long; gynophore glabrous, 4 or 5-angled, about 1 mm. in diameter, swollen at the base to a diameter of 2 mm.; anthers ovate, 2 mm. long, 1.5 mm. broad; ovary subglobose, densely hispidulous, glaucous; fruit globose, 2 cm. in diameter, hispidulous, glaucous; seeds somewhat compressed, obovoid, 4 mm. long, abruptly tapering at the base, mucronate at the apex, reticulate, the central mesh or the 2 central meshes 1 mm. in diameter, the surrounding 8 or 9 meshes averaging 0.8 mm. in diameter.

Type in the U. S. National Herbarium, no. 207,154, collected at Casillas, Department of Santa Rosa, Guatemala, September, 1892, by Heyde and Lux (J. D. Smith, no. 3772); distributed as "*Passiflora sicyoides* Cham.? aut n. sp.?" Duplicates in the Gray and John Donnell Smith herbaria.

In the shape of its leaves and the size of its seeds this species resembles *P. exsudans* Zucc. It is readily distinguished by the location of the petiolar glands at the apex of the petioles and by its densely hispidulous, glaucous fruit.

Passiflora (*Plectostemma*) **panamensis** Killip, sp. nov.

Glabrous throughout; stem angulate, grooved, flexuous; tendrils filiform, very slender; stipules linear-falcate, 4 to 5 mm. long; petioles 1.5 to 2.5 cm. long, glandless; leaves suborbicular in outline, 5 to 8 cm. long, 5 to 7 cm. broad, 3-lobed (the lobes approximate, subequal or the middle slightly

longer, about one-third the length of blade, triangular, acute or somewhat obtuse, mucronate), rounded or subpeltate at base, subpergamentaceous, 3-nerved, ocellate beneath ; peduncles 2.5 to 4 cm. long, articulate about 6 mm. below the flower; bracts setaceous, deciduous, two borne at the point of articulation, the third near the middle of the peduncle; flower about 3 cm. wide; sepals oblong-lanceolate, 1.2 to 1.4 cm. long, 6 to 7 mm. broad, obtuse, yellowish green; petals rose-colored, spatulate, 8 mm. long, 3 to 4 mm. broad; filaments of faucial corona in 2 series, the outer 7 mm. long, dilated and 3-angled toward the apex, the inner 3 mm. long, capillary and minutely capitellate; middle corona membranous, pink, plicate, erect, crenulate; basal corona annular; anthers linear-oblong 2.5 to 3 mm. long; ovary globose sparingly strigillose; styles subangulate, 3.5 mm. long; fruit globose, 2 cm. in diameter, glabrate; seeds straw-colored, obovate, apiculate, strongly flattened, transversely rugose with about 6 sharp somewhat rugulose ridges.

Type in the U. S. National Herbarium, no. 715,818, collected along the Sambú River, southern Darién, Panama, above the tide limit, February, 1912, by H. Pittier (no. 5556).

The lobation of the leaves of this species differs materially from that of its nearest allies. The arrangement and appearance of the coronae suggest *P. biflora*, but the flower is larger, the petals are rose-colored, and the leaves are distinctly 3-lobed, the middle lobe generally being slightly the largest.

Passiflora (*Plectostemma*) **rovirosae** Killip, sp. nov.

Stem 4-angled, striate, glabrate below, pubescent or pilosulous above; stipules narrowly falcate-subulate, 8 to 10 mm. long; petioles densely pubescent, 1.5 to 2 cm. long, glandless; leaves subtruncate-ovate in outline, 8 to 10 cm. long, 6 to 7 cm. broad, bilobate (lobes one-eighth to one-quarter the length of blade, somewhat divergent, acute, mucronulate), deeply cordate at base, slightly narrowed toward apex, membranous, above dark green, glabrate, or puberulent on the nerves, beneath pale, densely pubescent or tomentulous; peduncles 1 to 1.5 cm. long, 1-flowered, in pairs on short, axillary, often leafy, puberulent branches 1 to 2 cm. long, the inflorescence thus appearing racemose; bracts none; flowers 3 to 4 cm. wide; sepals oblong, 1.3 to 1.5 cm. long, 0.4 cm. broad, obtuse; petals oblong, obtuse, 0.9 to 1.1 cm. long, 0.3 cm. broad; filaments of faucial corona in two series, the outer filiform, about 1 cm. long, the inner capillary, barely 4 mm. long; middle corona membranous, erect, 4 to 5 mm. high, closely plicate; basal corona annular; gynophore angled, 7 mm. high, glabrous; ovary narrowly ovoid, 6-angled, canescent; anthers oblong, 4 mm. long, 1.5 mm. broad; styles capillary, 6 mm. long; stigmas reniform, 2 mm. broad; fruit ellipsoid or fusiform, tapering at both ends, 4 to 5 cm. long, 1.2 to 1.5 cm. in diameter at the middle.

Type in the herbarium of the Academy of Natural Sciences, Philadelphia, collected at Atasta, Tabasco, Mexico, June 15, 1890, by J. N. Rovirosa (no. 813). Photograph in U. S. National Herbarium.

ADDITIONAL SPECIMEN EXAMINED:

VERACRUZ: Misantla, *Purpus* 5881.

The fruit of this species indicates relationship with *Passiflora capsularis*,

from which it can be distinguished by its longer leaves and by the inflorescence. Its peduncles are borne in pairs on short, axillary branches, rather than singly in the axils of the leaves of the main stem.

Passiflora (*Plectostemma*) **talamancensis** Killip, sp. nov.

Stem angulate, striate, minutely puberulent; stipules linear-subulate, 3 to 8 mm. long; petioles 1 to 2 cm. long, puberulent or tomentellous, glandless; leaves cuneate-obovate or cuneate-oval in outline, 6 to 12 cm. long, 3 to 7 cm. broad, very shortly 3-lobed or 3-toothed at apex (middle lobe normally longest, 5 to 10 mm. long, usually deltoid), cuneate or rounded at base, narrowed above the middle, subcoriaceous, glabrous and lustrous above, dull and puberulent beneath, strongly 3-nerved, ocellate beneath; peduncles slender, 2 to 4 cm. long; bracts setaceous, 2 mm. long, deciduous; flowers 2.5 to 3.5 cm. wide; sepals oblong, obtuse, about 1.5 cm. long, 0.5 cm. broad, green without, white within; petals two-thirds as long as the sepals, white; filaments of faucial corona in two series, those of the outer series falcate-spatulate, 5 to 7 mm. long, white (?), those of the inner series capillary, 1.5 mm. long, white, purple at the tips; middle corona close to the faucial, membranous, plicate, 2 mm. long, erect, the margin minutely crenulate, slightly recurved; basal corona annular; gynophore glabrous, purple-striate; ovary globose, densely tomentellous; styles filiform, 4 mm. long; stigmas reniform; seeds ovate, 4 mm. long, 2 mm. broad, transversely rugose with 6 or 7 minutely rugulose ridges, asymmetrical, the margin bearing a single knob on one side just below the apex.

Type in the U. S. National Herbarium, no. 941,600, collected in forests at Xirores, Talamanca, Costa Rica, at an altitude of 100 meters, February, 1895, by A. Tonduz (no. 9329).

In texture the foliage of this species resembles that of *Passiflora trisetosa*. The leaves, however, are larger and more elongate, and the central lobe is much more prominent. The flowers of the two species present certain important differences. *P. talamancensis* has a 2-ranked faucial corona, an erect middle corona, and a globose, softly tomentellous ovary. *Passiflora trisetosa* has a single-ranked faucial corona, an incurved middle corona, and an ovoid, strigillose ovary.

Passiflora (*Granadilla*) **platyloba** Killip, sp. nov.

Stem stout, terete, striate, glabrous; stipules coriaceous, narrowly linear, 1 to 1.2 cm. long, strongly 3-nerved, orange-yellow, deciduous; petioles 6 to 7 cm. long, glabrous, bearing about 2 cm. above the base two sessile, flattened glands 2 mm. in diameter; leaves suborbicular-ovate in outline, 10 to 14 cm. long, 12 to 18 cm. broad, 3-lobed to the middle (the central lobe broadly ovate, abruptly acuminate, mucronate, 8 to 9 cm. long, 7 to 8 cm. broad, the lateral lobes divergent from the midrib at an angle of about 45°), at base deeply cordate, crenulate or subentire, biglandular in the sinuses, 3 to 5-nerved membranous, glabrous; peduncles solitary, 6 to 7 cm. long; bracts ovate, entire, 5 to 6 cm. long, 3 to 4 cm. broad, membranous, attached 1 cm. below the apex of the petiole, completely enveloping the flower, united for about 2 cm., acute, densely puberulent on both surfaces; flower purple, 4 to 5 cm. in diameter, the tube 1 cm. long; sepals oblong-lanceolate, 1.8 to 2 cm. long, 0.8 cm. broad, slightly fleshy, obtuse, strongly keeled, the keel terminating in a

setaceous awn 5 to 6 mm. long; petals linear-lanceolate, 1.5 to 1.7 cm. long, 0.5 cm. broad, thin, obtuse; filaments of faucial corona in several series, the outermost slender, filiform, 7 mm. long, the second series stout, liguliform, attenuate at apex, 1.5 cm. long, white, banded transversely with purple, the succeeding series of about 6 irregular rows of minute tubercles less than 1 mm. long; middle corona arising at base of the innermost of the latter rows, 0.75 mm. long, the margin erect, denticulate; secondary middle corona annular, midway between the preceding and base of gynophore, the margin entire; basal corona fleshy, closely surrounding and adnate to the lower part of gynophore, 3 mm. high, the margin free, erect; gynophore stout, grooved, glabrous, bearing 1 mm. above the margin of the basal corona a single annular process 0.4 mm. wide; filaments flattened, 7 mm. long, 1.2 mm. wide; anthers linear, 10 mm. long, 2 mm. broad; ovary elipsoidal, glabrate.

Type in the U. S. National Herbarium, no 678,715, collected at La Blasa de Río Grande, Province of Alajuela, Costa Rica, June 2, 1911, by H. Pittier (no. 3653).

This species resembles 3-lobed forms of *Passiflora seemanni*. Its bracts are much longer and completely envelop the flower; they are of a thicker texture, are acute rather than rounded at the apex, and are densely puberulent on both surfaces. The sinuses between the central and the lateral leaf-lobes are biglandular. In *Passiflora platyloba* the lower portion of the faucial corona consists of 4 or 5 definite rows of tubercles; in *P. seemanni* the tubercles are densely massed, apparently not being arranged in any definite order.

Passiflora (*Granadilla*) **purpusii** Killip, sp. nov.

Stem terete, striate, glabrate; stipules in pairs, foliaceous, semiovate, rounded at the base, cuspidate, 2.2 to 2.5 cm. long, 1 cm. broad, glabrous, dark green above, glaucous beneath; petioles 4 to 4.5 cm. long, glabrous, bearing in the upper half 4 to 6 stipitate glands 1.2 mm. long; leaves ovate, 10 to 13 cm. long, 5 to 9 cm. wide, long-acuminate, entire, shallowly cordate, membranous, above dark green and glabrous or minutely scabrous on the nerves, beneath glaucescent, pilosulous or occasionally glabrous, quintuplinerved from base; peduncles 3 to 3.5 cm. long, glabrous; bracts free to the base, ovate-oblong, about 1.5 cm. long, 7 mm. wide, glabrate, dark green above, glaucous beneath; flowers 4 to 5 cm. wide; sepals lanceolate or narrowly ovate-lanceolate, 2 cm. long, united at base for a distance of about 6 mm., cucullate at apex, keeled on the outer surface, the keel terminating in an incurved awn 5 mm. long; petals linear, 1 to 1.2 cm. long, 3 to 4 mm. broad; filaments of faucial corona in about four series, those of the outermost series narrowly linear, filiform at the tips, 1.2 to 1.5 cm. long, those of the succeeding series narrowly linear, slightly capitellate, nearly equal in length, 3 mm. long; middle corona membranous, erect or slightly incurved, the upper half cleft into linear threads; secondary middle corona a minute fleshy ring on the floor of the flower tube, halfway between middle corona and basal corona; basal corona membranous, erect, closely surrounding base of gynophore, 5 mm. high, the margin flaring outward, crenulate; gynophore glabrous, 1.3 to 1.5 cm. long (at anthesis); anthers linear, 8 mm. long, 2 mm. broad; ovary ovoid, glabrous; styles 8 mm. long; stigmas reniform; fruit not seen.

Type in the U S. National Herbarium, no. 877,596, collected at Zacuapan, Veracruz, Mexico, June, 1916, by C. A. Purpus (no. 7664). Duplicate in the herbarium of the University of California. *Purpus* 3689, from the same locality, is also this species.

Passiflora (*Granadilla*) **williamsii** Killip, sp. nov.

Stem stout, terete, minutely puberulent; stipules filiform, 6 to 7 mm. long; petioles 4.5 cm. long, densely puberulent, biglandular about 1 cm. from the base, the glands orbicular, appressed, 2 mm. in diameter; leaves broadly ovate in outline, 10 cm. long, 9 to 10 cm. broad, 3-lobed to middle (lobes acute, the middle one narrowed at base), serrulate, biglandular in the sinuses, at base truncate or slightly subcordate, 3-nerved, membranous, the upper surface glabrate, puberulent on the nerves, the lower surface minutely puberulent; peduncles 3 cm. long, densely pubescent; bracts united at the base, the free part 2 cm. long, 1.5 cm. broad, tomentulose on both surfaces; flowers about 6 cm. wide, the tube 1.2 cm. long; sepals oblong, 2.5 to 3.5 cm. long, 1.2 to 1.5 cm. broad, obtuse, puberulent without, glabrate within, inconspicuously keeled, slender-awned about 2 mm. from the apex, the awn 3 mm. long; petals oblong-spatulate, 2 cm. long, 5 mm. broad, greenish without, within white, spotted with dark pink; filaments of faucial corona in several series, the outermost terete, 6 to 7 mm. long, white, transversely banded with blue, the next series dilated at the middle, 2 to 2.5 cm. long, the succeeding series minute, tuberculate, 1.5 mm. high; middle corona arising close to the faucial, membranous, horizontally spreading inward, 2 mm. long, the margin entire, curved downward; secondary middle corona annular, midway between the preceding and the base of the gynophore; basal corona fleshy, closely surrounded and adnate to the lower part of the gynophore, 5 mm. high, the margin free, erect; gynophore 1.5 to 2 cm. high, 2 mm. in diameter, bearing about 7 mm. above its base a fleshy annular process 0.5 mm. wide, its margin recurved; filaments linear-spatulate, flattened, 1.5 mm. broad; anthers oblong, obtuse at both ends, 8 mm. long, 3 mm. wide; ovary narrowly ovoid, densely white-tomentulose; styles terete, glabrous; stigmas globose, 3 mm. in diameter.

Type in the herbarium of the New York Botanical Garden, collected at Bismarck, above Penonomé, Panama, altitude 600 to 925 meters, March 5 to 19, 1908, by R. S. Williams (no. 585). Photograph in the U. S. National Herbarium.

Passiflora williamsii belongs to the group of the subgenus *Granadilla* which is characterized by partially united bracts. From *P. seemanni*, *P. platyloba*, and *P. ligularis*, the other representatives of this group, it is readily distinguished by its leaves, which are truncate or very shallowly cordate at base and densely puberulent beneath. In the three other species the leaves are deeply cordate and entirely glabrous.

ZOOLOGY.—*New species and subspecies of* Sorex *from western America.*[1]

HARTLEY H. T. JACKSON, Bureau of Biological Survey.

Investigations upon American Soricidae for the United States Bio-

[1] Received April 27, 1922.

logical Survey show that in order to indicate properly the relationships of the various forms of the genus *Sorex* it is necessary to describe four new species and subspecies. Inasmuch as completion of my studies of this genus is now within sight, the descriptions and remarks on these new forms are here much abbreviated. More detailed descriptions and discussion of relationships will be presented in the monograph.

Sorex preblei,[2] sp. nov.

Type specimen.—No. 208,032, U. S. National Museum, Biological Survey collection; male adult (teeth moderately worn), skin and skull; collected July 3, 1915, by Edward A. Preble. Original number 5972.

Type locality.—Jordan Valley, altitude 4,200 feet, Malheur County, Oregon.

Geographic range.—Known only from eastern Oregon.

Diagnostic characters.—Smallest of the western forms of the *personatus* group; color paler and more grayish than in *Sorex personatus personatus;* hind foot small. Skull relatively flattened, small, with relatively short rostrum.

Color.—Summer pelage: Upperparts between hair-brown[3] and olive-drab, paling on the sides; underparts pale smoke gray very faintly tinged with cartridge buff. Tail above olive-buff basally, darkening to clove-brown toward tip; avellaneous below, darkening apically.

Measurements of type specimen.—Total length, 95; tail vertebrae, 36; hind foot, 11. *Skull:* Condylobasal length, 14.6; palatal length, 5.4; breadth of cranium, 7.1; interorbital breadth, 3.1; maxillary breadth, 4.2; maxillary tooth row, 5.1.

Sorex obscurus isolatus, subsp. nov.

Type specimen.—No. 177,719, U. S. National Museum, Biological Survey collection; male adult (teeth moderately worn), skin and skull; collected May 21, 1911 by F. Alexander Wetmore. Original number 517.

Type locality.—Mouth of Millstone Creek, Nanaimo, Vancouver island, British Columbia.

Geographic range.—Known only from Vancouver Island, British Columbia.

Diagnostic characters.—About the size of *Sorex obscurus obscurus* or *S. o. parvidens*, but darker than either, particularly on the ventral parts which are also decidedly more brownish. Unicuspidate teeth smaller than in *obscurus*, and the posterior borders of molariform teeth tending to be more deeply emarginate.

Color.—Winter pelage: Upperparts nearest chaetura drab mixed with grayish, gradually blending into color of underparts, which are smoke gray tinged with drab; tail indistinctly bicolor, olive-brown above, buffy brown to almost tawny-olive below.

Measurements of type specimen.—Total length, 113; tail vertebrae, 49; hind foot, 14. *Skull:* Condylobasal length, 17.4; palatal length, 6.6; breadth of cranium, 8.5; interorbital breadth, 3.5; maxillary breadth, 4.9; maxillary tooth row, 6.3.

[2] Named for the collector Mr. Edward A. Preble, friend and coworker, in recognition of his services and contributions to American mammalogy.

[3] Colors here used are those of Ridgway, *Color standards and color nomenclature,* 1912.

Sorex trigonirostris, sp. nov.

Type specimen.—No. 203,608, U. S. National Museum, Biological Survey collection; female adult (teeth slightly worn), skin and skull; collected May 5, 1914, by Luther J. Goldman. Original number 1308.

Type locality.—Ashland, altitude 1,975 feet, Jackson County, Oregon.

Geographic range.—Known only from near Ashland, Oregon.

Diagnostic characters.—Similar in size and color to *Sorex ornatus californicus;* mastoid region of skull more angular and prominent than in any other form of the *ornatus* group; rostrum shorter and more angular, the sides less outwardly curved than in *californicus.*

Color.—Summer pelage: Upperparts grayish hair-brown, becoming drab on the sides; underparts between pale smoke gray and pale olive-gray, very faintly tinged with pale olive-buff; tail olive-brown above, avellaneous below nearly to tip.

Measurements of type specimen.—Total length, 95; tail vertebrae, 34; hind foot, 12. *Skull:* Condylobasal length, 15.6; palatal length, 5.8; breadth of cranium, 7.9; interorbital breadth, 3.4; maxillary breadth, 4.5; maxillary tooth row, 5.5.

Sorex trowbridgii humboldtensis, subsp. nov.

Type specimen.—No. 97,271, U. S. National Museum, Biological Survey collection; male adult (teeth slightly worn), skin and skull; collected June 11, 1899, by Walter K. Fisher. Original number 914.

Type locality.—Carson's Camp, Mad River, Humboldt Bay, Humboldt County, California.

Geographic range.—Coast region of Humboldt and northern Mendocino Counties, California.

Diagnostic characters.—Intermediate in general between *Sorex trowbridgii trowbridgii* and *S. t. montereyensis.* About the color of *Sorex t. trowbridgii,* but tending to be larger, with larger and broader skull and heavier dentition. Averaging a trifle darker and less brownish than *Sorex t. montereyensis,* with relatively longer tail; skull with narrower rostrum and weaker dentition.

Color.—Summer pelage: Upperparts between deep mouse gray and chaetura drab or slightly paler; underparts similar in color to dorsal parts, scarcely if at all paler; tail sharply bicolor, fuscous to chaetura black above, whitish below.

Measurements of type-specimen.—Total length, 132; tail vertebrae, 62; hind foot, 14. *Skull:* Condylobasal length, 17.8; palatal length, 7.2; breadth of cranium, 8.9; interorbital breadth, 4.1; maxillary breadth, 5.4; maxillary tooth row, 6.7.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

857TH MEETING[1]

The 857th meeting (the 51st annual meeting) of the Philosophical Society was held in the Cosmos Club auditorium, December 3, 1921. It was called

[1] A report of the 858th meeting was published in this JOURNAL 12: 186–188. 1922.

to order at 8:15 p.m. by Vice-President WHITE. Thirty-nine persons were present.

The report of the Secretaries showed the present active membership of the Society to be 228, a gain of 15 during the year. The following officers were elected for the year 1922: *President*, E. C. CRITTENDEN; *Vice-Presidents*, J. A. FLEMING and D. L. HAZARD; *Treasurer*, W. R. GREGG; *Corresponding Secretary*, C. A. BRIGGS; *Members-at-large of the General Committee*, H. A. MARMER and IRWIN G. PRIEST.

At the conclusion of the business of the Annual Meeting , Mr. W. J. HUMPHREYS addressed the Society on the subject of *Fogs and clouds*. The address was illustrated by means of numerous lantern slides, and dealt particularly with the different kinds of clouds and their methods of formation.

859TH MEETING

The 859th meeting of the Philosophical Society was held in the Cosmos Club auditorium, January 14, 1922, with President CRITTENDEN in the chair, and 65 persons in attendance.

The address of the evening was given by the retiring president, R. L. FARIS, on *Some problems of the sea*. It was discussed by Messrs. ABBOTT, MARMER, SOSMAN, WILLIAM BOWIE, BURGESS, CRITTENDEN, and WHITE. It has been published in full in the JOURNAL of the WASHINGTON ACADEMY of SCIENCES (**12** : 117–132. 1922).

H. H. KIMBALL, *Recording Secretary*.

860TH MEETING

The 860th meeting was held jointly with the WASHINGTON ACADEMY OF SCIENCES at the Cosmos Club, January 28, 1922, President HUMPHREYS of the Academy presiding. In opening the meeting Dr. Humphreys stated that the snowfall during the preceding 24 hours had been more than double that recorded in Washington for any previous 24-hour period. The attendance at the meeting was 21.

Professor L. T. TROLAND of Harvard University read a paper on *Psychophysics as the key to the mysteries of physics and metaphysics*. This paper has been printed in full in the Journal of the Washington Academy.[2]

The paper was discussed by Messrs. HAWKSWORTH, WILLIAMSON, SOSMAN, PRIEST, CRITTENDEN, HEYL, FOOTE, H. E. IVES, TUCKERMAN, and HUMPHREYS.

E. C. CRITTENDEN, *Recording Secretary, Pro tem*.

861ST MEETING

The 861st meeting was held at the Cosmos Club auditorium, February 11, 1922, with President CRITTENDEN in the chair and 40 persons present. The following program was given:

EDWARD WICHERS: *The purification of certain elements in the platinum group*.

(Author's abstract.) The need for public information on the elements of the platinum group led the Bureau of Standards to conduct an investigation of the properties of these elements and their alloys. The precision required in the determination of physical properties made it necessary to prepare each of the elements in a state of highest possible purity. These very pure metals will also be used as material for the study of analytical methods for the platinum group.

[2] This JOURNAL **12**: 141–162. 1922.

Two methods for the isolation of a chemical individual were discussed. The first of these is the treatment of a solution containing two elements in such a way as to obtain a compound of one element with properties characteristically different from the analogous compound of the other element. An example was drawn from the treatment of a solution containing copper and silver with hydrochloric acid, forming a very slightly soluble chloride of silver and a very soluble chloride of copper, thereby permitting the isolation of silver.

The other method is required when the elements are so nearly alike in their properties that they react identically with all reagents. This condition is exemplified by the group of sixteen elements known as the "rare earths." This group forms complete series of isomorphous salts, and separations between two (or more) members are usually accomplished by fractional crystallization. In the platinum group either method may be used, although the former is used more frequently because it is more rapid. However, in one large platinum refinery, platinum is separated from iridium by the fractional crystallization of the isomorphous salts Na_2PtCl_6 and Na_2IrCl_6.

It is also possible by appropriate means to treat solutions of iridium and platinum in such a way as to reduce iridium from the tetravalent to the trivalent condition, without appreciably affecting the platinum. Iridium now behaves as a different chemical individual and its double chloride with ammonium chloride is quite soluble and not isomorphous with $(NH_4)_2PtCl_6$.

Such treatment would then effect a very rapid purification of platinum, except for the phenomena of "co-precipitation," which is very marked in this whole group of elements. Because of this the precipitate of $(NH_4)_2$-$PtCl_6$ is contaminated with iridium, and the preparation of platinum in a high degree of purity is made possible only by several re-precipitates of the compound named.

In the purification of palladium use is made of the characteristic compound dichlorodiammine-palladium-$Pd(NH_3)_2Cl_2$. For rhodium two salts are used, the first refining being accomplished by the use of the insoluble salt K_3Rh-$(NO_2)_6$, and the subsequent preparation of chloro-pentamine, rhodium chloride $(Rh(NH_3)_5Cl)Cl_2$. For iridium no similar characteristic compound is known and iridium must be purified by the opposite procedure of removing other elements from the solution first.

Ruthenium and osmium may be separated from the other platinum elements through the volatile tetroxides RuO_4 and OsO_4.

In the case of platinum, palladium and rhodium, it is to be noted that in each case a salt is chosen which may be ignited directly to metal, leaving no other nonvolatile constituents.

Brief mention was made of the work done on the precautions necessary to avoid contamination in the melting of the purified platinum sponge.

C. O. Fairchild: *Thermo-electric tests for the purity of some metals* (illustrated).

(Author's abstract.) The thermo-electric test is performed by making a thermocouple of two metals and measuring its e. m. f. at a known temperature; for example two pieces of gold from different sources may be compared at the melting point of gold. If the thermal e. m. f. is large, one or both of the samples are quite impure. If the e. m. f. is small then time is well spent in further study of the samples. The test is particularly suited to comparing metals of the highest purity, containing only spectroscopic traces of one or a very few metals.

Knowledge of the thermoelectric effect of small traces of impurities is limited. A thermoelectric difference is irrefutable evidence of difference of the two metals. (These should be carefully annealed so that the physical condition is constant.) No difference, that is a negative result, raises doubt. Perhaps more than one impurity gives opposite effects.

Special study has been made of pure platinum, pure gold and pure palladium, the purity being of the highest order. In the three cases the purest samples as selected by other tests have been the most negative thermoelectrically. As an illustration of the magnitude of the e. m. f's. afforded by traces of impurity, two pieces of platinum one spectroscopically free of any detectable impurity and one indicating the faintest trace of calcium (or lime) as an impurity, gave a thermal e. m. f. of about twenty micro-volts at 1200° C. Probably there is a very wide variation in the effect of constant amount of different impurities.

As a beginning, a series of platinum rhodium alloys, containing respectively 0.001%, 0.01%, 0.1%, 0.5%, and 1.0% of rhodium were made. Spectroscopic examination gave no evidence of impurity. The e. m. f. of each alloy against platinum at 1083° C. was measured. It was found that the e. m. f. was proportional to the rhodium content up to about 1.0%. The accuracy of the whole procedure, including the synthesis and electrical measurement, was ± 4 microvolts from strict proportionality. All these alloys are positive to platinum. This is not the case with gold-palladium alloys which will be tried next to show whether or not the thermoelectric effect of a trace of an impurity is the same in sign as the two metals of the alloy. Is 99.999% Pd-.001% Au positive to palladium?

W. F. MEGGERS: *Spectrographic tests for the purity of some metals* (illustrated).

(Author's abstract.) In connection with the purification of certain elements in the platinum group carried out by Dr. Wichers at the Bureau of Standards, spectrographic analysis was employed to indicate the progress of purification and to detect the traces of impurities present in the final product. The metals were vaporized and ionized in a high potential electrical spark with capacity and self-inductance in the circuit. Alloys or mixtures of elements made luminous in this source give, simultaneously, the spectra of all the elements present and these spectra are recorded photographically with the aid of a quartz or a concave grating spectrograph. If one observes the spectra of a series of mixtures in which one element is progressively diluted it is seen that the spectrum of this element becomes simplified, more and more lines disappear, as the dilution increases, until a single line remains faintly visible when a mere trace of the element is present. These most sensitive lines were called "raies ultimes" by DE GRAMONT[3] to whom much credit is due for developing the principles of this method of analysis.

The raies ultimes are exceptionally sensitive for all metals and remain visible when the concentration of an element in an alloy or mixture is even less than 0.0001 per cent. A trained observer after studying the partial spectra of carefully prepared standard samples can apply this information to making rapid and fairly accurate quantitative analyses of similar alloys of unknown percentage composition. The empirical basis for such spectrographic tests has been developed at the Bureau of Standards, especially for the analysis of mint gold and of platinum metals. Some of the physical constants of metals,

[3] DE GRAMONT. Ann. Chim. et Phys. VIII, 17: 437. 1909.

particularly the thermal electro-motive force and thermal coefficient of electrical resistance, are sensitive even to spectroscopic traces of impurities. The spectograph showed that when the purest platinum sponge was fused on lime or magnesia it was usually contaminated with traces of calcium and magnesium but when fused on thoria no impurities could be detected. With the aid of this method of spectrographic analysis platinum metal has been prepared which is positively 99.9999 per cent pure.

Discussion of the three papers was participated in by Messrs. BURGESS, WHITE, FOOTE, L. H. ADAMS, HARPER, and HUMPHREYS.

862D MEETING

The 862d meeting of the Philosophical Society was held in the Cosmos Club auditorium, February 25, 1922, with President CRITTENDEN in the chair and 54 persons present. The program was as follows:

R. S. WOODWARD: *The calculus of harmonics and preharmonics and their application in hydromechanics.* It was discussed by Mr. L. A. BAUER.

(Author's abstract.) A harmonic function, H, is defined to be any homogeneous function of x, y, z, which satisfies Laplace's equation. That is, H is a harmonic if

$$\frac{\partial^2 H}{\partial x^2} + \frac{\partial^2 H}{\partial y^2} + \frac{\partial^2 H}{\partial z^2} = 0.$$

This equation is now, for brevity, commonly written

$$\Delta^2 H = 0, \text{ or } \Delta H = 0.$$

and the operation thus symbolized is called the Laplacian of H.

Conformable to these definitions, a preharmonic function, P, is defined to be any homogeneous function of x, y, z which satisfies the equations

$$\Delta^2 P = H, \ \Delta^2\Delta^2 P = \Delta^2 H = 0.$$

Corresponding to every harmonic function, therefore, there is a preharmonic function determined by the integral of the first of the last two equations; and since there is an extensive range of harmonic functions, of which the degrees may be positive or negative integers, or fractional or imaginary numbers, there is a coextensive range of preharmonic functions.

While harmonic functions have been investigated in elaborate detail, it does not appear that much attention has been given to the intimately related functions here called preharmonics. It was the object of the paper to outline the characteristics of these functions and the calculus to which they lead, as well as to indicate some of their more important applications. General formulas for all of the preharmonics corresponding to all the harmonics of positive and negative integral degrees were given.

L. A. BAUER: *Some results of recent earth-current observations* (illustrated).

(Author's abstract.) Renewed interest was aroused by the remarkable earth-current disturbances of May 14 to May 30, 1921, which, as will be recalled, occurred simultaneously with brilliant displays of polar lights and severe magnetic storms, the sun at the time showing remarkable spot activity. These disturbances and accompanying phenomena occurred over the entire earth. Northern lights were observed in lower northerly latitudes than usual and southern lights were observed as far north in the Southern hemisphere as Apia, Samoa—a very unusual occurence. In many respects the disturbances during the period, May 14 to 20, 1921 were similar to

those which occurred during the period, August 29 to Sept. 4, 1859; in this latter case, northern lights were visible as low as 18° north. The magnetic disturbances for the latter period were of almost unexampled size and rapidity, the accompanying aurora being extraordinarily brilliant and e. m. f's. of 700 to 800 volts are said to have been reached on telegraph lines 500 to 600 km.

Since Oersted's discovery somewhat over a century ago of the deflection of a compass needle by an electric current, hypotheses have been repeatedly advanced respecting the earth's magnetic field as caused by electric currents in the earth's crust. However, most of the earth-current observations made up to the present date indicate that the constant part of the observed current along a parallel of latitude is chiefly towards the east, instead of towards the west, as would be necessary to account for the observed phenomena of the magnetic needle.

At the International Electric Congress, held in Paris in 1881, such interest was aroused that systematic investigation of earth currents, especially as observed in telegraph lines, was undertaken in various countries. This material was furnished for Weinstein's well-known publication in which data obtained on two telegraph lines (Berlin to Thorn and Berlin to Dresden) from 1884 to 1887, were successfully utilized.

Unfortunately, the interest then aroused has waned and, as far as known, there is at present only one observatory where systematic earth current observations are being made, namely, at the Observatorio del Ebro, Tortosa, Spain, where the series of observations began in 1910. The speaker proposes to arouse renewed interest in this important subject at the forthcoming Rome meeting of the International Geodetic and Geophysical Union.

The Department of Terrestrial Magnetism is planning to install earth-current lines for systematic observations at its magnetic observatories. This year, it is hoped that such lines may be installed at the Department's Observatory at Watheroo, Western Australia. Various initial investigations have been in progress at the Department's Laboratory and Dr. Mauchly made a report to our Society some years ago. To Mr. O. H. Gish, appointed recently as Associate Physicist of the Department, has been assigned the continuation of these investigations. Furthermore, in order to take advantage of the experience in such work gained at the observatory in Spain and to ascertain the direction in which further study is desirable, a discussion of the eleven-year series at the observatory mentioned was undertaken under the direction of the speaker.

Slides were shown exhibiting the relations between variations of earth-currents, especially of the diurnal variations, and solar activity during the eleven years cycle. The relations between the diurnal variations of earth-currents and those of the earth's magnetic elements were also briefly discussed. It would appear that the relations are of a rather complicated character.

863D MEETING

The 863d meeting was held at the Cosmos Club March 11, 1922, with President CRITTENDEN in the chair and 70 persons present.

WILLIAM BOWIE: *The yielding of the earth's crust* (illustrated). It was discussed by Messrs. WASHINGTON and HAYFORD.

(Author's abstract.) The theory of isostasy postulates that blocks of the crust of the earth are in equilibrium. The investigations carried on by the U. S. Coast and Geodetic Survey and the Trigonometrical Survey of India

lead us to believe that the theory of isostasy is substantially true and that the amount of matter in blocks of the crust of equal cross section at the depth of compensation is very nearly equal in various parts of the earth.

Since the earth's crust is in hydrostatic or isostatic equilibrium now it is a logical conclusion that it has been so during the earlier geological periods and therefore we must conclude that movements within the earth's crust which are recorded in geological strata and structures did not materially increase the amount of matter in any block of the crust.

There are four rather distinct movements of material within the earth's crust or at its surface. First the transportation of material by wind and water from one place to another over the surface. Second, a downward movement of the material of the earth's crust under the area of sedimentation, some of this movement being due to a yielding under the load of the sediment and the remainder to thermal contraction and a contraction due to physical or chemical action. Third, a movement below the earth's crust, in a more or less horizontal direction, of material which is yielding to long continued horizontal stress. This material flows from the block of the earth's crust on which sediments are placed toward the block from whose surface material was eroded. The fourth is the upward movement of the material in a block of the earth's crust under the area of erosion. As the material is eroded from the surface, the isostatic balance is restored by the entering of material at the bottom of the block, thus causing the block to rise.

It seems to be reasonably certain that mountain systems are caused by a vertical uplift due to local causes rather than to horizontal thrusts resulting from forces acting from great distances. The distortions of sedimentary rocks which are visible in most elevated regions appear to be incidents to the sinking of an area under sedimentation and to subsequent uplifting of the area. As an area once subject to sedimentation is uplifted, and since this uplift must be a result of a change in density within the block, the upward movement would follow lines of least resistance. The direction of such lines would frequently be inclined to the vertical and at times be almost or quite horizontal.

The change in density in a block of the earth's crust which has undergone heavy sedimentation may be due to the fact that the material of the block has been pushed down into regions hotter than that originally occupied. The shrinking and increase of density of a block under an area of erosion may be due to the fact that many thousands of feet of material had been eroded, thus resulting in the raising of the material of the block below the area into regions that were much cooler than that which the material had originally occupied. This change in temperature, which may be as much as 200 or 300 degrees Centigrade, may cause a thermal contraction as well as an increase in density due to physical or chemical changes other than the thermal expansion.

It is certain that the theory of isostasy must be taken into consideration in geological investigations, especially those having to do with dynamic and structural geology.

H. V. SVERDRUP: *The scientific work of the present Amundsen Arctic Expedition* (illustrated). It was discussed by Messrs. MARMER and BEALL.

(Author's abstract.) Captain Amundsen's Expedition left Norway in July, 1918, with the intention to follow the coast of Siberia eastward to the vicinity of Bering Strait, proceed thence towards the north, let the vessel, the "Maud," freeze in and drift with the ice fields across the Polar Seas back

to the Atlantic Ocean. The main object of the Expedition was to study the physical conditions of the Polar Sea, but along with the oceanographical work, a number of other observations, mostly of geophysical interest, were to be carried out. However, the Expedition was forced by the ice conditions to winter three times in different places on the coast of Siberia.

The first wintering took place close to Cape Chelyuskin, the north point of the Asiatic continent. During this winter, registrations of the meteorological elements, the magnetic declination and the tides were secured. A tidal gage, adapted to the special conditions met with, was made on board. Numerous direct observations were also made. The difficulties in observing at low temperatures did not arise so much from the effect of the cold upon the observer, who could dress conveniently, as from the effects upon the instruments, particularly the inevitable formation of frost upon eye-pieces and verniers. In the spring the Chelyuskin Peninsula was explored on sledge trips covering over 1000 miles.

When leaving Cape Chelyuskin, Captain Amundsen decided to send all observations home with two men, who were to bring them to the nearest settlement, a Russian wireless station at Dickson Island. These men lost their lives. All records from the self-registering instruments are lost with them, but copies of all absolute observations exist.

The second wintering took place at Ayon Island, 700 miles west of Bering Strait. The speaker spent the winter among the natives, a group of the Chukchi tribe, gathering information of ethnological interest. Magnetic observations were taken at a series of stations from Kolyma River to Bering Strait, and meteorological and tidal registrations and observations were kept up on board the "Maud."

After a call at Nome in July, 1920, the "Maud" was frozen in for the third time, only 80 miles west of Bering Strait. During the winter, additional information about the natives was secured on a two and one-half month's sledge trip along the coast; the series of magnetic stations was extended to Holy Cross Bay, and registrations were kept up on board.

In the summer of 1921, the vessel of the Expedition had to be sailed to Seattle for repairs. Capt. Amundsen intends to start out from Seattle in June, 1922, and will once more try to penetrate to the drifting ice fields in order to accomplish the drift across the Polar Sea.

864TH MEETING

The 864th meeting was held at the Cosmos Club March 25, 1922, with President CRITTENDEN in the chair, and 35 persons in attendance.

The President announced that the Recording Secretary expected to be absent from Washington until July, 1922, and that Mr. H. A. MARMER had been designated to act as Secretary *pro tem* during this period. Program:

C. O. FAIRCHILD and W. H. HOOVER: *A disappearing filament optical pyrometer free from diffraction effects at the filament* (illustrated, presented by Mr. Fairchild). It was discussed by Messrs. CRITTENDEN and HUMPHREYS.

(Author's abstract.) This pyrometer consists of a telescope or microscope in the focal plane of which is a small electric lamp. To estimate temperature of an object, its brightness is matched with that of the lamp filament by adjusting the current through the lamp. An equation such as $I = a + bt + ct^2$ may be used to interpret current values.

For measuring high temperatures this pyrometer is particularly suited, but one of its supposed faults, and a source of uncertainty in its accuracy, has

been the effect of diffraction of the light focussed in the plane of the filament, by the filament.

A rigorous solution of the problem of diffraction by an obstacle in the focal plane has not been attempted. It can be shown by deduction that only the light diffracted by the objective aperture is again diffracted by the filament; while the undiffracted portion of the converging beam passes the filament undisturbed. To avoid a visible effect of diffraction the filament and image are viewed through an aperture smaller than the objective in angular measure. The actual values of the entrance and exit apertures of the telescope depend on various factors. Large entrance apertures must be used.

As a result of improvements in the design of this optical pyrometer, the precision attainable has been markedly increased, now surpassing, probably, that of the contrast photometer. High temperatures are easily estimated to fractions of a degree, far within the limits of certainty of the so-called high temperature scale. The disadvantage lying in the use of the optical scale founded on the Wien-Planck laws, instead of the radiation scale of Stefan-Boltzman laws, is balanced by the extreme ease of manipulation and high precision attainable. However, the lack of agreement between the different scales of temperature is at present not great, nor serious, and has been found negligible for most purposes.

A form of micropyrometer has been devised for measuring the temperature of a microscopic or very small object with the same precision as with large objects. For example a small lamp filament or a minute black-body furnace can be examined.

The writers believe that significant progress has been made toward placing this form of optical pyrometer in sound relation with the laws of geometrical and physical optics, and in developing an instrument of precision.

S. P. FERGUSSON: *Equipment for aerological kite-flying at the greatest possible heights* (illustrated). It was discussed by Messrs. L. H. ADAMS, CRITTENDEN, HUMPHREYS and TUCKERMAN.

(Author's abstract.) With kites and accessories in use at the present time the average heights attained are about 3500 meters and the maximum about 7000. From an experimental study of materials, forms of kites, methods of construction, lines, etc., the author has found that these heights can be increased considerably if the largest kites and the largest sizes of wire for lines are used. Large kites are more economical and are so much stronger than smaller ones of nearly the same specific weight that there is no danger of wrecking a kite in the strongest wind likely to be encountered aloft; also they are steadier and more stable and since their specific weight when carrying the usual recording instruments is smaller, ascensions are possible through a wider range of conditions. By the use of curved lifting-surfaces the average altitudes can be increased to about 64°, or nearly 8° higher than that attained by kites with flat surfaces, and curved-surfaced kites will maintain a higher altitude in strong winds.

A new method of building kites was described whereby the time and cost of constructing aerological kites is less than one half that required to produce kites of the usual patterns and the processes of adjustment and repairing greatly simplified.

With kites and accessories described in which harmful resistances have been reduced to the lowest point easily attainable, ascensions may be extended to a greater average height than has been possible heretofore with less labor and

smaller risk to valuable apparatus; also, by taking advantage of favorable conditions, it appears possible to reach the level of the cirrus clouds, and the base of the stratosphere, or a maximum height of approximately 10,000 metres.
H. H. Kimball, *Recording Secretary.*

ENTOMOLOGICAL SOCIETY

341ST MEETING

The 341st regular meeting was held June 2, 1921, in Room 43 of the National Museum with First Vice-president GAHAN in the chair, and 16 members and 6 visitors present.

The program consisted entirely of *Notes and exhibition of specimens.*

Dr. L. O. HOWARD spoke of the Hessian fly parasite *Entedon epigonus.* An attempt was made to introduce this species into the United States thirty or more years ago. It was recovered by FORBES the second year later and by ASHMEAD seven years later, but had apparently disappeared thereafter. It is now breeding abundantly in three localities.

Dr. HOWARD also told of having attended a recent meeting of the American Entomological Society in Philadelphia and spoke in high praise of a talk given at the meeting by MORGAN HEBARD on a trip to Colombia.

A. B. GAHAN expressed doubt if the presence of *Etendon epigonus* is due to the artificial introduction, pointing out that it has ample opportunities to be introduced accidentally.

A. N. CAUDELL recorded the finding in Washington of two masses of eggs of the praying mantis, *Ptenodera chinensis.* Mr. ROHWER stated that he had liberated some in Falls Church, Virginia, and that they had disappeared after a few days and none had been found since.

H. S. BARBER discussed a new strawberry pest discovered at Miami, Florida, by Mr. MOZNETTE. This is a bluish green weevil of the genus *Atypus.* E. A. SCHWARZ discussed the confusion of names in this genus, which is common to the West Indies and the southeastern part of the United States as far north as New Jersey. S. A. ROHWER spoke of Hymenoptera common to both regions, and stated that variation is greater in Porto Rico than in Cuba or the United States. A. B. GAHAN mentioned the bracoinid *Apanteles grenadensis* Ashm. (synonym, *A. harnedi* Vier.), a parasite of *Laphygma frugiperda.* This species occurs in the West Indies, Brazil, and in the United States as far north as Tennessee. Mr. CAUDELL stated that certain Orthoptera known to occur in Florida and Costa Rica do not occur in the West Indies. Mr. SCHWARZ stated that there was formerly a land connection between the West Indies and Yucatan.

R. A. CUSHMAN spoke of the synonymy of certain species of *Amblyteles,* which synonymy was proved by the introduction of the species into Hawaii and their subsequent recovery.

C. T. GREENE announced the return by Dr. FELT of the National Museum material of *Itonididae.* This consists of 775 slides embracing 71 genera and 267 species, 174 being type material. There is also determined the work of 40 species.

A. N. CAUDELL exhibited a copy of the very rare paper by KELCH, *Grundlage zur Kenntniss der Orthoptera Oberschlesiens,* in which appeared for the first time some of FIEBER'S genera. He also spoke of the value to the working entomologist of a well catalogued library of separates.

W. B. WOOD told of the finding at the inspection house of a living larva of the pink boll worm in wild cotton from India. This cotton has small seeds and the larva was working from the outside. Mr. BARBER stated that the insect feeds in the same way on okra seed.

Dr. HOWARD told of the death by suicide of the Russian Entomologist KJURDUMOV.

S. A. ROHWER spoke of a paper by Prof. COCKERELL on the Bees of Madeira. Madeira originally had no bee fauna and all the present species are related to the Palearctic forms.

342ND MEETING

The 342nd meeting was held October 6, 1921, at the National Museum, with First Vice-president GAHAN in the chair and 28 members and 10 visitors present.

J. M. ALDRICH: *Collecting in Alaska.*

Dr. ALDRICH gave an account, illustrated by lantern slides, of his summer's collecting in Alaska, during which he traversed the entire length of the government railway. He also described the differences in climate, topography and flora of the various parts of the road, and mentioned some of the more interesting insects, especially Diptera, that he captured. He commented especially upon the great abundance of mosquitoes and the apparent absence of the house fly.

Notes and exhibition of specimens

Dr. J. M. ALDRICH exhibited photographs of two series of exuvia of larvae of the museum pest, *Trogoderma tarsale*, one showing the decrease in size from instar to instar in starved larvae, and the other showing the successive instars of a single larva that had been alternately starved and fed for nine years During this period it had three times attained maximum size and twice decreased practically to first instar size.

A. N. CAUDELL read a note from his entomological journal recording his observations on a specimen of the psammocharid wasp, *Anoplius illinoiensis* Robertson. This wasp was apparently bathing, during the operation descending into the water to the depth of three inches and walking on the bottom.

R. A. ST. GEORGE gave some phenological records on cerambycids in comparison with plant events in 1921. The season in this respect was as a whole abnormal, but especially in two species, *Neoclytus erythrocephalus* and *Xylotrechus colonus*, each of which passed through two generations instead of the normal one generation.

Dr. A. L. QUAINTANCE exhibited apples from Wenatchee, Washington, injured by the pear leaf blister mite.

A. B. GAHAN spoke of having recently received a specimen of *Pachycrepoideus dubius* Ashm., a chalcid parasite of diptera, reared from the cheese skipper, *Piophila casei*. This is the first record of a parasite of this species of which he had heard.

J. C. BRIDWELL exhibited living specimens of the Bethylid, *Sclerodermus macrogaster*, and briefly outlined the habits of members of the genus, which live gregariously on insect larvae, feeding both as larva and as adult on the juices of the host.

R. A. CUSHMAN, *Recording Secretary.*

BOTANICAL SOCIETY

155TH MEETING

The Botanical Society held its 155th regular meeting at the Cosmos Club, on December 6, 1921, with President SAFFORD in the chair.

Prof. DAVID LUMSDEN and Mr. FRED C. MEIER were elected members of the Society.

A communication was received from Mr. C. R. BALL in reference to an autograph letter from HENRY MUHLENBURG, the noted botanist, written September 25, 1809 to Dr. JOHN OTT at Georgetown, D. C., enclosing a list of 195 species of plants apparently collected by Dr. Ott in the vicinity of Washington, D. C.

The Secretary then read a letter from Mr. SHAPOVALOV and one from Dr. L. R. JONES of the National Research Council, to the effect that the movement fostered by the Botanical Society to secure American scientific literature for Russian scientists had met with success, and the National Research Council approved this project and had appropriated $1,000 to carry out the plan. Mr. Shapovalov's efforts as a committee of one from the Botanical Society to the Washington Academy of Sciences to consider sending literature to Russian scientists have come to a successful end and he desires to terminate his appointment.

Under *Brief notes and reviews of literature* Dr. SHANTZ presented the second volume of Burgerstein's work on transpiration. This brings the review of literature down to 1920.

Mr. M. B. WAITE told of seeing specimens of *Myrica carolinensis* collected near Camp Meade. Dr. FAIRCHILD stated that a specimen of *Myrica rubra* from China collected by Mr. Frank Meyer fruited at Chico, California and at Brooksville, Florida. This species represents a large fruit industry in China.

The regular program was as follows:

F. WILSON POPENOE: *Hunting new plants for American horticulture in the highlands of Central and South America* (illustrated).

For some years the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry has been engaged in studying the wild and cultivated avocados of tropical America, and in introducing the most promising ones for trial in California and Florida. In both these States avocado culture is now established on a commercial basis, and the demand for new varieties of this fruit, to fill certain needs such as different seasons of ripening, is keen.

The two years' exploration reviewed in this talk covered the most impor tant avocado-growing regions between Guatemala and Chile. In the former country, where 16 months' work had already been done in 1916–1917, a large quantity of avocado seeds of known parentage was obtained for use in producing stock-plants on which to graft superior varieties of this fruit. In Costa Rica several promising kinds were obtained and sent to Washington, also seeds of the *aguacate de anis*, a wild avocado of considerable interest. In Colombia a study was made of the numerous avocados found in the Santa Marta regions, as well as those of Cundinamarca and the Cauca Valley; and one variety was sent to the United States for trial. In Ecuador a number of very choice forms were found in a region hitherto unknown as a producer of good avocados. A brief study was made of the various sorts which grow in Peru and Chile, but none was found worthy of introduction into the United States.

In addition to avocados, numerous other economic plants were investigated, and propagating material of the most promising was sent to Washington. In Guatemala a thousand plants were obtained of the *pacayito*, a handsome dwarf *Chamaedorea* suitable for house culture; seeds and plants of several wild blackberries were collected, as well as seeds of the handsome *Dahlia maxonii* and other plants.

In Costa Rica a particular study was made of the *pejibaye* palm (*Guilielma utilis*), and a quantity of seeds was secured; seeds of several interesting species of Rubus, and other plants, were likewise sent to Washington.

In Colombia many interesting and little-known plants were studied. Perhaps the most striking is *Rubus macrocarpus*, the giant Colombian Berry, of which plants were sent to Washington.

From Ecuador were sent many varieties of the potato, including the wild form; a cultivated variety of *Fragaria chiloensis;* a large-fruited form of *Prunus salicifolia;* several varieties of *Rubus glaucus*, *R. adenotrichos*, and other species of Rubus; several hardy Caricas, and other plants.

From Chile were sent numerous aphis-resistant varieties of the apple; several peaches, plums and cherries of Chilean origin; three cultivated forms of *Fragaria chiloensis;* and the Capuchine orange, a dwarf variety of *Citrus sinensis*.

LOUIS C. C. KRIEGER: *A sketch of the history of mycological illustration (Higher Fungi).*

The development of the methods employed in mycological illustrating was traced from the time of Clusius (1601) to Boudier (1910). It was pointed out that truthful illustrations add much to the completeness of the record of so perishable a plant as a fleshy fungus.

Clusius was taken as the starting-point of the historical sketch for the reason that his illustrations (especially the original water-colors from which the wood-cuts in Clusius' work were made, which have recently been published by Istvanffi) are the first truthful figures available to the mycological systematist, those of the herbalists, prior to Clusius, often showing fanciful embellishments.

The gradual development of the technical processes, from wood-engraving through copper-engraving, lithography, half-tone, heliogravure, and tricolor printing, was described by the speaker, illustrations from the classic works of Schaeffer, Bulliard, Letellier, Sowerby, Greville, Fries, Tulasne, and Boudier, serving as examples of the progress in technique.

In concluding his remarks, Mr. Krieger spoke of the dearth of published colored illustrations of American origin, and the hope was expressed that Dr. Howard A. Kelly, of Baltimore (with whom Mr. Krieger is associated in mycological work) might succeed in publishing an illustrated revision of the late Prof. Peck's monographs.

This paper, with suitable illustrations, is to be published elsewhere in full The address was illustrated by lantern slides as well as by copies of several rare mycological books, and by a score or more of Mr. Krieger's own artistic studies of some of the higher fungi.

ROY G. PIERCE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The National Academy of Sciences held its annual meeting in Washington on April 24, 25, and 26. The scientific sessions open to the public were held

in the Museum auditorium on the first two days of the meeting. Among the members of the Smithsonian staff who read papers were Secretary C. D. WALCOTT, *The new building of the National Academy and National Research Council;* Dr. L. O. HOWARD, *A side effect from the importation of parasites of injurious insects;* Dr. ALEŠ HRDLIČKA, *Stature amd head form in Americans of old families;* AUSTIN H. CLARK, *Animal evolution;* DR. ABBOT, Mr. FOWLE, and Mr. ALDRICH, *The larger results of 20 years of solar radiation observations.*

The third International Conference on Chemistry will be held at Lyon, France, June 27–July 2, 1922, under the direction of the *Fédération Nationale des Associations de Chimie de France.* It will be followed by the second congress of industrial chemistry, organized by the *Société de Chimie Industrielle,* at Marseilles from July 2 to 7.

The Smithsonian Institution has recently made arrangements for the resumption of exchange relations with Roumania, the Institutal Meteorologic Central, Ministerul Agriculturei, Bukharest, having offered to act as the Roumanian Agency. The Institution is now sending exchange consignments to all foreign countries except Jugoslavia, Russia, and Turkey. The following newly established governments are included among these to which shipments are being forwarded: Czechoslovakia, Esthonia, Finland, Latvia, Lithuania, Poland.

The United States National Museum has recently secured by purchase, through the cooperation of the United States Department of Agriculture, the large private herbarium of Dr. OTTO BUCHTIEN, formerly Director of the Museo Nacional, La Paz, Bolivia, built up by him through many years of botanical exploration in South America and through exchanges with institutions in many parts of the world. The herbarium consists of approximately 45,000 specimens, and is notable for its large proportion of tropical American species, particularly of the floras of Bolivia, Chile, Argentina, and Paraguay.

Among the delegates to the meeting of the International Geophysical Union at Rome are Drs. L. A. BAUER, Department of Terrestrial Magnetism, Carnegie Institution of Washington; HENRY S. WASHINGTON, Geophysical Laboratory, Carnegie Institution of Washington; WILLIAM BOWIE, Coast and Geodetic Survey; G. W. LITTLEHALES, Hydrographic Observatory; and H. H. KIMBALL, Weather Bureau.

The Alaskan Mineral Resources Division of the U. S. Geological Survey has been raised to a Branch, and Mr. A. H. BROOKS is now designated the Chief Alaskan Geologist.

A shipment of material collected in the Province of Fukien, southeastern China, has recently been received from ARTHUR DEC. SOWERBY. It contains many birds and animals not previously represented in the National Museum. This is the first shipment received from Mr. Sowerby from southeastern China, a section of the country from which the Museum has very little material. Through Mr. Sowerby's previous work the mammal fauna from northern China is now very well represented in the Museum, making this South China material of special interest.

Eighteen of the ornithologists of Washington met at the home of B. H. SWALES on March 14, 1922, for the purpose of organizing an ornithological club. As it was the intention at the start to meet at members' homes for informal social intercourse, the number had necessarily to be restricted, and twenty-five was fixed as the limit and only men primarily interested in birds considered. Dr. T. S. PALMER was named temporary chairman and upon

vote it was decided to call the society the "Baird Club." Dr. A. K. FISHER was elected president, NED HOLLISTER, vice-president, and B. H. SWALES, secretary.

The Archives of the Bureau of American Ethnology have been enriched through a gift from W. B. CABOT, of Boston, of a collection of about 3,700 Algonquian names with their variations in spelling. These names for the most part are not found in Lithgow's Algonquian dictionary.

The meeting of the Petrologists' Club at the home of H. G. FERGUSON on February 14 was devoted to a discussion of West Indian petrology. W. S. BURBANK and H. S. WASHINGTON discussed the rocks of Haiti; F. H. MOFFIT, those of Cuba; and C. P. ROSS, those of Santo Domingo. H. S. WASHINGTON described the chemical and physical properties of some Central American jades which are of archeological as well as petrological interest.

A meeting of the Pick and Hammer Club was held on Saturday, March 25, at the Geological Survey, with the following program: J. S. BROWN: *Unusual springs in the Republic of Haiti;* F. W. CLARK: *The composition of surface waters of the United States with respect to areal geology and climate, and the interpretation of the latter factors from water analyses.*

S. R. Capper, geologist in the U. S. Geological Survey, has been furloughed for a year to do commercial work abroad for an American company.

WILLIAM T. CARRIGAN, one of the senior assistants in the Nautical Almanac Office, U. S. Naval Observatory, died at Washington, D. C., on January 20, 1922. He assisted in the research work carried on by the late Prof. SIMON NEWCOMB, and published a number of papers on astronomy.

CHARLES HENRY DAVIS, 2nd, Rear Admiral, retired, U. S. Navy, twice Superintendent of the Naval Observatory, died at Washington, D. C., December 27, 1921. He graduated from the Naval Academy in 1864, and from 1875 till 1885 was engaged principally in astronomical work, at first in the Naval Observatory at Washington, in the Department of Chronometers, and then in expeditions for the determination of longitudes by means of the submarine cables. His publications refer chiefly to the results of such work in various parts of the world.

GEORGE R. DAVIS, Topographic Engineer in charge of the Pacific Division of the U. S. Geological Survey, died on March 31, and Mr. T. G. GERDINE has been put in charge of that division, including Hawaii.

Miss FRANCES DENSORE, collaborator of the Bureau of American Ethnology in Indian music, has collected during the past winter 101 Yuma, 40 Cocopa, and 10 Mohave songs in addition to other important musical material. Among the most important novelties are remarkable observations on a "Memorial," or cremation ceremony held annually by the Mohaves over those who have died during the year.

NEIL M. JUDD, Curator of American Archeology, left for New Mexico on May 1 to resume direction of the National Geographic Society's Pueblo Bonito Expedition. During Mr. Judd's absence JOHN L. BAER will again serve as Acting Curator of American Archeology.

Dr. WILLIAM M. MANN has returned from his South American trip, in which he was Director of the Mulford Biological Exploration on the upper Amazon for several months. He brought back over a hundred live animals and extensive collections of many kinds, especially of insects.

Mr. GLENN S. SMITH has been assigned charge of the Rocky Mountain Division of the U. S. Geological Survey. He will also retain supervision of the Division of West Indian Surveys.

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OCEANOGRAPHY.—*The applications of science and engineering in the work of the United States Lighthouse Service.*[1] GEORGE R. PUTNAM, Lighthouse Service, Department of Commerce.

The Lighthouse Service has a definite function to perform, the providing of marks or signals to guide vessels in their proper course and to keep them away from danger. In performing this duty it makes extensive use of apparatus and appliances developed through scientific research, and of structures, both on land and afloat, in many cases involving difficult engineering problems. The aids, over 16,000 in number, are either on unfixed or floating structures, slightly more than half being floating. As to character, they fall into three general groups, lights, fog signals, and daymarks, though many aids combine these three functions or two of them.

Lighthouses and other lighted aids.—Though in many respects the fog signals are the aids most needed by the mariner, yet the lights are the more numerous and more widely known marks, and their development will be first described.

The outermost lights are those of the outside lightships, which are in effect floating lighthouses anchored off the coast and in the approaches to the great seaports. These are few in number, only 22 for the Atlantic, Gulf and Pacific coasts, but they are the guides most used by the larger class of vessels, as they can run directly for these lightships without risk of stranding if somewhat off in reckoning. An example is the Nantucket light vessel, anchored 41 miles off the land; this is the mark for which most of the vessels crossing the north Atlantic direct their course westward bound. There are now also a number of large sea gas buoys anchored off the coast and entrances.

The primary coast lights are the principal lighthouses marking prominent headlands, offlying islands and rocks, important entrances, and some intermediate points. On a well lighted coast these primary

[1] Address delivered at the Bureau of Standards, May 5, 1922. Received May 15, 1922.

lights are so spaced that a vessel skirting the coast will always be in sight of one of these lights.

There are a great number of smaller lights, such as gas buoys marking channels and immediate entrances, and lighthouses and post lights marking minor entrances, inside channels, dangers, and river channels.

The problems to be solved in providing an effective light for the mariner are: most useful location, suitable illuminant, lamp and optical arrangement to give the required luminous range, height of the light for the proper geographic range, and distinctive characteristic to avoid confusion with other lighted aids as well as lights for other purposes.

Because of expense involved, the number of lights must of course be restricted to the most essential locations. They are placed as near as practicable to the track of vessels, or to the outer limit of the danger to be marked; large expenditures have sometimes been made so as to place a lighthouse in the position most protective to shipping. The geographic range, depending on the height of the focal plane above sea level, is for the primary lights on low coasts about 20 nautical miles, this distance being sufficient for general navigational purposes. This requires a tower of from 150 to 200 feet, depending on the elevation of the observer on the ship. Adding another 100 feet to the height of a tower of 200 feet increases the distance of visibility only $3^1/_2$ nautical miles.

Illuminants and lighting apparatus.—For illuminant, the primary coast lights of this country now use kerosene burned in incandescent oil vapor lamps. In this lamp the kerosene, forced into the vaporizer by air pressure, is heated and vaporized, and is burned mixed with air under a mantle, which is thus brought to a brilliant incandescence. This lamp gives one candlepower of the bare light for about $^3/_4$ gallon of kerosene a year, as against 6 gallons a year per candlepower for the Argand wick lamp, thus increasing the illuminating efficiency of the oil about 8 times. As an example, when the oil vapor lamp was installed at Cape Hatteras lighthouse the power of the light was increased from 27,000 to 80,000 candles, and the consumption of oil was reduced from 2,300 to 1,000 gallons a year. Next to kerosene, acetylene gas is the most widely used illuminant, supplying nearly 1,000 lights in this service, for the most part unattended beacons on shore, and gas buoys. These are nearly all supplied with compressed gas dissolved in acetone, in tanks filled with a porous substance; the acetone has the

remarkable power of absorbing many times its own volume of gas. This makes a safe and economical system for unattended lights and buoys. Electricity is not generally used at primary lights because of expense, sufficient illuminating power being obtained at much less cost with the oil vapor lamp; electricity is, however, used with great advantage at some stations where supply of current is available, particularly at harbor stations where distant control is desirable, as a station at the end of a breakwater where the light may be controlled from the shore end. An automatic arrangement for exchanging lamps in case of burnout is used.

The early lighthouses were lighted with open fires, and tallow candles were used at the Eddystone light for more than a hundred years. Although lighthouses have aided the mariner for more than 2,000 years, most of the progress in illuminating apparatus and fog signals has been made during the last century. A hundred years ago coal fires and tallow candles had only recently been abandoned at important lighthouses in England, guns were still used as fog signals, and no outside lightship had yet been moored off the coast of this country. The French physicist, Fresnel, in 1822, a hundred years ago this year made the greatest single step in the improvement of illuminating apparatus by developing a built-up annular lens surrounded by rings of glass prisms, the central portions of which refract and the outer portions both reflect and refract the light from a single source lamp placed at the focus. This lens was for a fixed light, and its effect was to concentrate the light in a plane useful to the mariner, but distributed around the horizon. Great progress has since been made by the use of lenses constructed in panels, and rotated, thus concentrating the light in beams sweeping around the horizon, and showing to the mariner a flash or group of flashes with definite characteristic. Great illuminating efficiency and much reduced cost have been obtained with such apparatus, by using smaller lenses, concentrating the light through a small number of panels, and revolving at high speed. The latter is made possible by carrying the weight of the rotating lens in mercury in an annular trough. The following comparison shows the great advantage of the modern lens arrangement: At Seguin, Maine, with first order lens 72 inches in diameter, the light, which is fixed, has 22,000 candlepower. At Molokai, Hawaii, there is a second order two panel lens, 55 inches in diameter, revolving once in 20 seconds, and giving each 10 seconds a flash of 620,000 candlepower. At the latter the cost of oil per candlepower per year is only about $^1/_{30}$ of a cent. With the

most complete lenses about 60% of the light is rendered useful, the balance being lost at the top and bottom, and through absorption by the glass of the lens and lantern.

Most of the important lights, and a large proportion of all the lights, have distinctive characteristics, to avoid the serious danger of mistaking the identity of the light. Color is used to some extent, but is undesirable excepting for minor lights because of the large loss of light, about 60%, even with the most efficient color, red. Modern installations at important stations have distinctive characteristics through the use of revolving lenses. Older installations of fixed lights have been changed into occulting by the use of some form of moving shutter or screen, much less efficient optically than the revolving lens, as the light is not concentrated into beams Acetylene gas and electricity lend themselves to efficient arrangements for flashing lights. With the former, a small pilot flame burns continuously, and an ingenious flashing device discharges a supply of gas from the tank at uniform intervals of time.

Fog signals.—Fog and other conditions rendering objects invisible constitute the greatest menace to safety of shipping, and call for every help that science can give to vessels thus imperiled. The development of fog signals has lagged much behind the improvement of lighted aids. The first fog signals in this country were guns, fired occasionally and it was a hundred years after the building of Boston lighthouse before a fog bell was installed on our coast, and not until about 60 years ago were the first air and steam signals used, and it is only recently that a system has been developed permitting the taking of bearings on invisible signals, by means of the radio compass and radio signals.

The conditions as to fog differ greatly in different regions; the North Atlantic coast of the United States and portions of the Pacific and Alaska coasts are extremely foggy, while on the South Atlantic and Gulf coasts and in Porto Rico and Hawaii there is little fog. The highest record of fog for a year is 2,734 hours, or 31% of the total time, at Seguin Light Station, Maine. There is a record of $7^1/_2$ days of continuous fog at a station, requiring the operation of a fog signal 181 hours without cessation. The distribution of fog signals along the coasts, of course, conforms to the conditions as to amount of fog, as well as the intricacy and importance of navigation. Thus along the Atlantic coast north of Cape Lookout are located 334 fog signals (exclusive of sounding buoys), or considerably more than half of those maintained by this Service.

The radio fog signal is believed to be the most valuable of the future, because it is the first fog signal permitting of the taking of accurate bearings and effective at considerable distances. It was made possible by the development of the radio compass or radio direction finder at the Bureau of Standards. The system consists of equipment installed at lighthouses or on light vessels, for sending out radio signals of a distinctive character, and of radio compasses mounted on ship board, with which bearings of the radio signals may be taken. The compass coil mounted on the ship consists of a few turns of wire in a vertical plane, mounted over a magnetic compass or a graduated arc on which bearings can be read, and with receiving and amplifying devices. The coil rotates about a vertical axis, and when the plane is parallel to the direction of the signal the intensity of the sound is a maximum, and when it is perpendicular to the direction the signal is a minimum. The latter condition is used in taking bearings. Radio compasses, mounted on tenders of the Service, are now being regularly used in navigation. The Lighthouse Service has a number of radio fog signals in operation, and others are being established.

The Navy as a result of experience developed during the war, has established along the coast a number of radio compass stations, operating as a part of its coast communication system, and prepared to give bearings to vessels asking for same, this being the reverse of the Department of Commerce system providing for having the radio compass on the ship.

The fog signals at present in general use give warning by sound transmitted through the air; they are sirens, diaphones, and horns operated by compressed air, steam whistles, and bells actuated by weights and clockwork. There are also bells struck under the water operated by compressed air or electricity, which transmit sounds through the water, and there is now under test a more powerful apparatus of this sort, an oscillator, consisting of a heavy steel disc, which is set in vibration by electric power.

The sound in air fog signals is the aid very widely used throughout the world at the present time to warn and guide vessels in fog and other periods of low visibility. It has the advantage of simplicity of observation, being available, within its range, to every person of normal hearing. Although a somewhat crude solution of the navigational problem, it has undoubtedly immensely aided and safeguarded the movement of the shipping of the world. It has serious drawbacks as an aid to navigation, however. The distance at which even the most

powerful sound in air signals may be heard varies greatly, and under unfavorable weather conditions such signals can be heard only at a moderate distance, affording scant protection; there are many cases of aberration of the sound, the signal being lost and again picked up at a greater distance, and no means are available to the ordinary navigator of taking a definite bearing on a sound fog signal.

The steam whistle is a fog signal formerly extensively used; an important objection to it is the time required to get it in operation, as fog may come with but brief warning and the signal should be in operation at once. The most effective sound-producing fog signals are the siren and the diaphone using compressed air supplied by air compressors, driven by internal combustion engines. These signals have distinctive notes, and can be started very quickly on the approach of fog. In the standard form of siren now used in the Lighthouse Service, a hollow cylinder or rotor, 6 inches in diameter with peripheral slots is revolved in a casing with similar slots, leading to a horn or trumpet. The blasts are controlled by clockwork, giving a characteristic signal at each station. The diaphone is an instrument similar to the siren, but having a reciprocating motion instead of a rotary one.

Sounding buoys, operated automatically by the sea, are much used aids, and serve a very valuable purpose within moderate distances. The greater number are the familiar bell buoys; a modification of this has recently been made, obtaining a chime effect by means of several sizes of gongs, with clappers striking alternately. Bell buoys are so balanced as to operate with every slight motion of the waves. The whistling buoy is an American invention, and is a valuable aid where there is sufficient sea to operate it effectively. Submarine bells have been installed on buoys, the movement of the buoy operating a large vane, which winds a spring actuating the striking mechanism. The most valuable recent improvement is the installation on a buoy of a bell operated by carbonic acid gas. The gas tanks are placed in receptacles in the buoy, and the bell is struck at uniform intervals by a piston actuated by the gas pressure.

About half a century ago considerable research work in sound as affecting fog signals was done by Joseph Henry, then chairman of the Lighthouse Board, as well as Secretary of the Smithsonian Institution, and the results were collected in the latter's report for 1878. About 20 years ago elaborate comparative tests of fog signal apparatus were conducted by the Trinity House of London, at St. Catherines Point,

Isle of Wight, with the advice of Lord Rayleigh. In recent years comparative tests of apparatus have been made by the Lighthouse Service from time to time, and the fog signal station at Execution Rocks in Long Island Sound has recently been fitted up for systematic tests.

Lighthouse construction and engineering.—Unusual engineering problems are involved in the lighthouse work both in the fixed and floating structures. Most of the important lighthouses have been built on exposed sites, and many on submarine sites, or partially submerged reefs, involving difficult engineering design and construction. The problems will be illustrated by a few examples. Minots Ledge lighthouse, south of Boston, was built on a reef bare only at low water and for a small area, and exposed to the Atlantic. The reef had to be cut to receive the foundation of the tower; during the first year only 130 working hours were obtained on the rock, and the work was prosecuted for more than 3 years before a single stone was laid. After 5 years' work a massive stone tower was erected, which has now stood for over 60 years; on occasions the waves go over the top of the tower, 97 feet above the water.

On the Pacific coast, a notable lighthouse is that at Tillamook Rock, south of the mouth of the Columbia River. Here the top of the rock had to be blasted off to give a site for the structure, and special protection had to be provided for workmen and materials, as in storms the waves go over the entire rock. The lantern of the completed structure is 133 feet above the sea, but in severe storms rocks have been thrown through the lantern glass.

A number of lighthouses have been erected in open water on sand bottom, with caissons sunk by the pneumatic process. The first so built in this country was the Fourteen Foot Bank lighthouse in Delaware Bay, standing in 20 feet of water. The caisson was sunk to a depth of 33 feet into the sand, using a timber working chamber 40 feet square.

Marking the edge of the Florida reefs are six tall iron lighthouses, five of which stand in shallow water. As the material of the coral reefs was not solid enough to sustain on piles alone the weight of these towers, from 115 to 160 feet in height, sufficient support was obtained by driving wrought iron piles into the coral, to a shoulder resting against iron discs 8 feet in diameter, giving a large bearing on the surface of the coral.

Vessels and floating aids.—More than half of the aids maintained are floating, and these are of great value to mariners, as they can be

placed directly at the point most useful in marking a danger, or in defining a safe course; they have the disadvantage of being liable to be displaced or sunk, but this is to some extent overcome by improved design, heavier moorings, and constant watchfulness by the Lighthouse Service vessels and people.

The Service has about 120 vessels in commission, light vessels or floating lighthouses, and tenders, or supply steamers. Both of these classes require vessels of special design. Important problems of naval architecture have to be solved, particularly in the plans for the light vessels. This country maintains these on 49 stations, of which 22 are exposed stations in the open sea. To remain anchored on a station off the coast, exposed to the full force of storms, is a service not expected of any other ship, and for a long time difficulty was had in designing vessels that would meet the requirements. It was 73 years from the first attempt before a lightship was successfully maintained on Diamond Shoal off Cape Hatteras, and because of this difficulty elaborate attempts involving possible large expenditures, were made to build a lighthouse on the Outer Diamond Shoal. In the design of lightships, the lines are shaped to control the rolling and the easy riding of the vessel in a seaway. The framing is heavy, and ample water-tight bulkheads are provided. Flush deck construction is used with a minimum of upper works, so as to allow seas to sweep over the vessel. The bow is high to ride the seas. The largest light vessels in this Service are only about 135 feet in length. They are moored with mushroom anchors up to 7500 pounds in weight on the exposed stations, with heavy mooring chains, 180 fathoms or 1,080 feet in length, weighing approximately 28,000 pounds. The chain passes through a hawse pipe in the stem, near the water line, so that the vessel may ride as easily as possible. Lightships anchored in the more exposed positions are subjected to most severe treatment by the combination of gales and cross currents, and every precaution is taken to secure their safety, and their remaining on station. The modern vessels are self-propelled, and the strain on the mooring chains during storms is relieved by judicious use of the propelling machinery. At a few stations a spherical mooring buoy is shackled to a submerged portion of the chain to carry a part of the weight and ease the strains due to the vessel surging.

The lighthouse tenders are the supply and construction vessels, and care for the buoys and lightships. They are equipped with powerful hoisting gear for handling the heavy buoys and moorings,

and have large open deck space forward for the stowage of buoys. They must be of moderate draft so as to go into close waters to place the buoys, and at the same time must be good sea boats, for their work takes them out to sea, some times under severe weather conditions.

The Service maintains many types of buoys, of which the most important are the lighted buoys, and the sounding buoys, already mentioned. The other buoys are of iron or wood, and indicate by their color and number their position with respect to the channel.

Problems in Alaska.—There are special problems to be met in some regions, as for instance Alaska. Here water navigation is very important, as the territory is largely dependent on it for transportation, and the conditions as to fog, reefs and rock-bound coasts, and water depths render navigation difficult. The remoteness makes lighthouse maintenance expensive, particularly for attended stations, and because of the very extensive coast line as complete a system of aids as on the North Atlantic coast would be beyond the financial resources of the government. In the past 12 years the number of aids in Alaska has been increased more than threefold, and many lights, suitable for the inside passages, have been added at moderate maintenance expense by the installation of acetylene gas apparatus. Important additions are still needed, particularly in the way of fog signals.

The U. S. Lighthouse Service.—In closing I will briefly refer to the Lighthouse Service in general. It lights and marks all the coasts and interior navigable waters of the United States and its possessions excepting the Philippine Islands and Panama. It maintains 16,000 aids to navigation and is the most extensive service of its kind in the world under one organization. It is conducted through 19 lighthouse districts, each under a Superintendent, who is charged with a wide local responsibilty for the proper upkeep of the district. The responsible officers of the Service are engineers or other technical men, with long experience in the work. There is on Staten Island, New York Harbor, a general supply station, and shops where considerable special equipment is manufactured for the Service, and where some tests and experimental work are carried on. The Service makes very extensive application of the results of scientific research, but it has, however, not attempted to establish any large research division, because of the existence in the Department of Commerce of the Bureau of Standards, and the excellent assistance and cooperation given by that organization.

The first lighthouse in this country was built by Massachusetts at Boston, in 1716, and this station is still in operation. Several other lighthouses were built by the colonies. The maintenance of the lighthouse system was the first public work, or work of a technical character, undertaken by the United States Government, being provided for at the first session of Congress in 1789.

CRYSTALLOGRAPHY.—*Crystallographic-optical properties of calcium fumarate and maleate.*[1] EDGAR T. WHERRY and RAYMOND M. HANN, Bureau of Chemistry.

Crystals of these salts do not appear to have been measured heretofore. They are, however, of interest in that the acids represent a simple case of stereoisomerism, so we have prepared them and studied them in detail.

CALCIUM FUMARATE, $Ca(C_4H_2O_4).2H_2O$

Preparation.—The fumaric acid was obtained from a commercial firm now making it in a high state of purity by a catalytic process. After several trials the following plan was found to yield the best crystals of the calcium salt: Dissolve $2^1/_2$ grams of fumaric acid in 50 cc. of water, heat to boiling, neutralize with 30% KOH solution, and then acidify slightly by the addition of a small amount of the acid. To the boiling solution add an equal volume of 5% $CaCl_2$ solution and continue boiling until a slight turbidity appears. Filter the solution, cover loosely and allow to stand for several weeks. Groups of bladelike crystals as much as 2 mm. in length then separate out. Before removing them for study the solution is best placed in a cold place for a time to cause the crystals to take up material and repair any corrosion which their faces may have suffered.

Composition.—On ignition the salt was found to yield a residue of CaO equivalent to 28.47%, indicating the presence of 2 molecules of water of crystallization (theory, 29.5%).

Crystallography.—It was found that where crystals lay close together in groups their angles were somewhat distorted, but it was possible to pick out several fairly free from such disturbances, and five of these were submitted to crystallographic measurement. They are orthorhombic and tabular on a pinacoid, with marginal dome-prism forms.

In an orthorhombic crystal a choice of six orientations is open to the

[1] Contribution from the Analytical Reagents Investigation Laboratory and Laboratory of Crystallographer. Received May 20, 1922.

describer; and in the present substance the single pinacoid present might be made either *a*, *b*, or *c*, while in each of these cases the dome-prism forms might be placed in either of two positions. The conventional rule about such matters is to place the direction of greatest elongation vertical, and make a dominant pinacoid face *b*. When this is done for calcium fumarate, its angle data come out as shown in Table 1.

TABLE 1.—ANGLES OF CALCIUM FUMARATE IN CONVENTIONAL ORIENTATION.
Orthorhombic; $a : b : c = 0.3970 : 1 : 0.3772$ ($p_0 = 0.9503$; $q_0 = 0.3772$).

Number Letter	Symbols Gdt.	Mill.	Description	Angles φ	Observed ρ
1 b	0∞	010	Dominant form	0°00′	90°00′
2 m	∞	110	Longer marginal form	68°21′	90°00′
3 q	01 .	011	Shorter marginal form	0°00′	20°40′

It may be noted that this substance lies very near to the mineral columbite, $FeCb_2O_6$, which, in corresponding orientation, has $a : b : c = 0.4023 : 1 : 0.3580$.

There is, however, another method of orientation which in many respects seem preferable, namely, that worked out by the late Professor E. S. Fedorov.[2] Unfortunately his rules have not yet been made available to non-Russian readers in complete form. The first step seems to be to bring the crystal into that orientation which shall show most clearly its relationship to a system of higher symmetry. In the present case, it takes but brief inspection of the habit to realize that this substance approaches the tetragonal system if the large pinacoid is made the base, and this is the orientation adopted for the second angle table. The substance is, in fact, as far as the angles go, markedly peritetragonal. According to Fedorov,[3] the tabular habit perpendicular to axis *c* indicates that the axial ratio should be strongly positive—that is, axis *c* should be much greater than the others. As a matter of fact, whichever axis is taken as *b*, the value of *c* is greater than $2^1/_2$, so that thus far the relations are normal.

Next there is a choice between making the dome with the smaller rho angle the side dome or the front dome; in the former position, axis *a* would be less than axis *b*, in the latter, greater than *b*. Since *b* is by convention taken as the unit axis, it seems preferable to make *a* greater than *b*, and as this also agrees with Fedorov's rule, the greater elongation of the crystal being toward the greater rho, the dome with the smaller rho angle has been turned to the front, that is, made form (101). The dome with the larger rho angle then becomes (011), and

[2] *Z. Kryst. Min.* 50: 513. 1912.
[3] *Loc. cit.*

the axial ratio given at the head of the angle table is the result. Fedorov termed the orientations worked out on the basis of his rules the "correct setting," but any one of the six orientations of an orthorhombic crystal is just as correct as any other, so the term "significant" is preferred, since what is meant is that orientation which best brings out the relations of the crystal to other systems.

TABLE 2.—ANGLES OF CALCIUM FUMARATE IN SIGNIFICANT ORIENTATION

Orthorhombic; $a : b : c = 1.0523 : 1 : 2.6510$ ($p_0 = 2.5193$; $q_0 = 2.6510$). Peritetragonal, with deviation of prism angle φ from the tetragonal value $= 1°28'$.

Number letter	Symbols Gdt.	Mill.	Description	Angles φ	Observed ρ
1 c	1	001	Dominant form	....	0°00′
2 e	01	011	Narrow but brilliant	0°00′	69°20′
3 d	10	101	Like e, but longer	90°00′	68°21′
....	1	111	(Calculated)	43°32′	74°43′

The crystals are usually distorted in such a manner that one dome face of each pair is decidedly larger than the other, the symmetry being thus ecto-hemimorphic. Their average habit is shown in Figure 1.

Space relations.—The topic axes of the substance were next calculated. As the usual plan for doing this obscures the relations somewhat, it becomes preferable to first calculate unit-volume axes, which differ from the usual crystal axes in that axis b is no longer taken as unity, but is reduced to such a value that the product of all their axes equals one. The unit volume axes may be distinguished from the ordinary axes by the use of capital letters. The formulas used are: $A = \sqrt[3]{a^2/c}$; $B = A/a$; $C = c \times B$. Using the values obtained from the significant orientation of Table 2, the results are: $A : B : C = 0.7475 : 0.7104 : 1.8832$.

The molecular weight of calcium fumarate, $Ca(C_4H_2O_4).2H_2O$, is 190.1. Its specific gravity was determined by suspending a few crystals in a mixture of carbon tetrachloride and bromoform, the amounts of the constituents being varied until the crystals remained suspended, when the specific gravity of the liquid was obtained with a Westphal balance. As variation from one crystal to another was shown, some floating in the same liquid in which others sank, it would be meaningless to state the result beyond the second place; it was 1.71 ± 0.01. The molecular volume is accordingly 111.2 and the cube root of it 4.81. Multiplying the unit-volume axes by this factor, the topic axes are: $\chi : \psi : \omega = 3.60 : 3.42 : 9.06$.

Optical properties.—Study by the immersion method under the polarizing microscope shows calcium fumarate to be biaxial negative

with a small axial angle, but extreme double refraction. It has the form of rectangular plates and irregular angular fragments, with refractive indices of $\alpha = 1.413$, $\beta = 1.602$ and $\gamma = 1.611$, all ± 0.003. The double refraction is thus 0.198, and $2V$ calcd. $= 22°24'$, $2E$ calcd. $= 36°16'$, $2E$ obs. $= 37° \pm 1°$. The optical orientation, however, is not what might have been expected from the peritetragonal crystal form; for $X = a$, $Y = b$ and $Z = c$, so that perpendicular to the pinacoid it is not the acute but the obtuse bisectrix which is visible.

The mean refractive index $n = 1.539$, from which the refractivity may be derived, using the formula $M = V \times (n^2 - 1)/(n^2 + 2)$ (V being molecular volume, already determined). This gives $M = 34.8$, the significance of which value is discussed after the data for calcium maleate are given.

CALCIUM MALEATE, $Ca(C_4H_2O_4).H_2O$

Preparation.—A number of unsuccessful attempts were made to prepare this salt in a form suitable for crystallographic measurement, but the crystals were in general too minute to handle. After experimenting to determine the best strengths of the solution to employ, the following plan was adopted, the acid used coming from the same source as the fumarate: Dissolve 5 grams of maleic acid in 50 cc. of H_2O, heat to boiling, neutralize with 30% KOH solution, and slightly acidify with additional acid. To the boiling solution add an equal volume of boiling 10% $CaCl_2$ solution, and continue boiling until the slight bumping which often precedes precipitation is noticed. Filter rapidly into a vessel kept at about 80°, by immersion in a large water bath, cover closely and allow the bath to cool. When cooling is rapid, rosette groups of needle-like crystals form; when it is gradual, a continuous crust, which ultimately develops into interlacing needles, deposits. After some days the vessel is placed on ice for a time and the crystals are removed and dried.

Composition.—On ignition the salt was found to yield a residue of CaO equivalent to 32.38%, showing the presence of one molecule of water of crystallization (theory 32.6%).

Crystallography.—The crystals obtained are not altogether satisfactory, for although the prism faces are fairly well developed and do not give excessive variation in angles, the terminations seem always to be dull or rounded. However, by measuring ten crystals and taking the average values of the angles a fairly close approximation to the probable values could be obtained. It is noteworthy that the more

rapidly cooling crystals had a series of steep domes forming a more or less continuous curve, while those that cooled more slowly had but a single flat dome. The system, as with the fumarate, is orthorhombic.

In standard orientation, placing the direction of elongation vertical and the pinacoid at the side, the angles of Table 3 are obtained.

TABLE 3.—ANGLES OF CALCIUM MALEATE IN STANDARD ORIENTATION

Orthorhombic; $a : b : c = 0.779 : 1 : 0.643$ ($p_0 = 0.825$; $q_0 = 0.643$).

Number letter	Symbols Gdt.	Mill.	Description	Angles φ	Observed ρ
1 b	0∞	010	Narrow and sometimes lacking	0°00′	90°00′
2 m	∞	110	Dominant form	52°05′	90°00′
3 q	01	011	Principal termination	0°00′	32°45′
4 r	06	061	Part of long curved form	0°00′	76°±
5 s	08	081	Part of long curved form	0°00′	79°±

This is close to the mineral chalcostibite (wolfsbergite), $CuSbS_2$, which has $a : b : c = 0.8026 : 1 : 0.6275$.

In this case as before the standard orientation is not the significant one, for the prism angle is over 7° away from the theory for the tetragonal, while the principal dome has a phi angle less than 3° away from the theory for a more symmetrical system, in this case the hexagonal. Turning the pinacoid to the front, in order to make axis b the shortest one, this gives the angles and axial values of Table 4 and Figure 1.

TABLE 4.—ANGLES OF CALCIUM MALEATE IN SIGNIFICANT ORIENTATION

Orthorhombic; $a : b : c = 1.555 : 1 : 1.211$ ($p_0 = 0.779$; $q_0 = 1.211$). Peri-hexagonal, with deviation of prism angle φ from theory for hexagonal 2°45′.

Number letter	Symbols Gdt.	Mill.	Description	Angles φ	Observed ρ	Calculated φ	Calculated ρ
1 a	∞ 0	100	Narrow and sometimes lacking	90°00′	90°00′	90°00′	90°00′
2 k	8∞	810	Part of long curve	79°±	90°00′	79°00′	90°00′
3 l	6∞	610	Brightest part of long curve	76°±	90°00′	75°28′	90°00′
4 m	∞	110	Principal terminal form	32°45′	90°00′	(32°45′)	90°00′
5 d	10	101	Dominant form	90°00′	37°55′	90°00′	(37°55′)
...	1	111	(Calculated)	....	....	32°45′	55°13′

Space relations.—Calculating the unit-volume axes as before, the results are: $A : B : C = 1.259 : 0.810 : 0.981$. The specific gravity determined by the same method as in the preceding case, was decidedly greater, 1.84 ± 0.01. The molecular weight being 172.1, this gives the molecular volume 93.5 and its cube root 4.54, making the topic axes $\chi : \psi : \omega = 5.72 : 3.68 : 4.45$. No relation can be traced with the corresponding values for the fumarate.

Optical properties.—Calcium maleate is like the fumarate biaxial and negative, but its refractive indices are much higher and the double

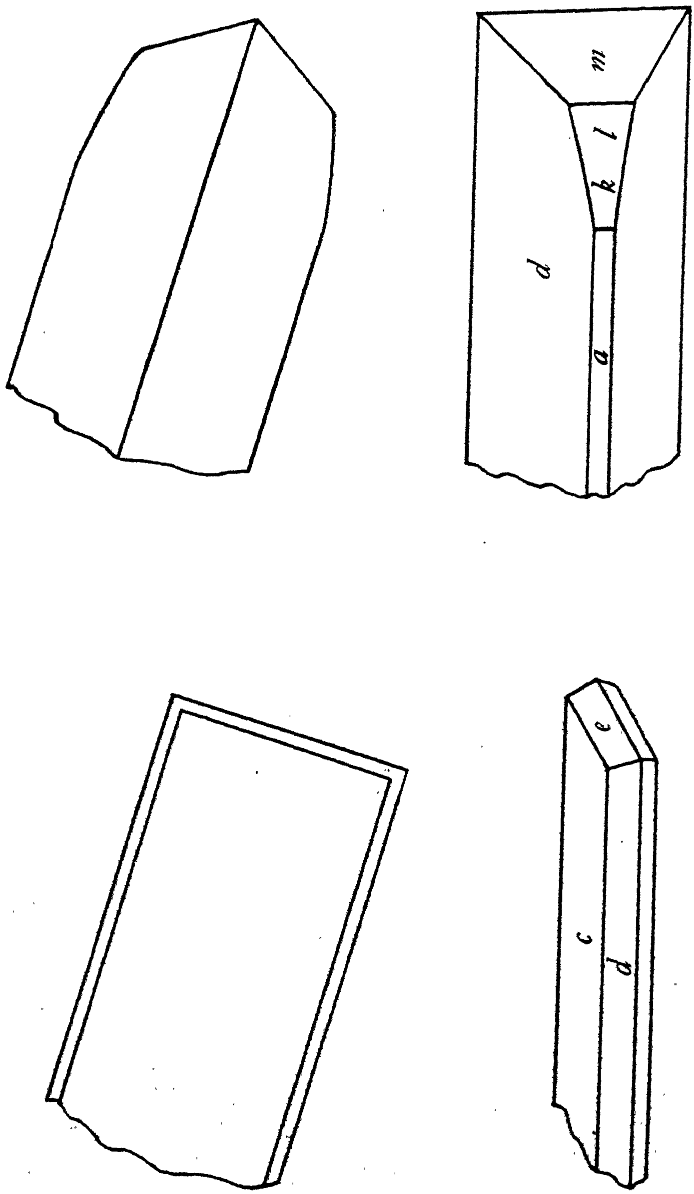
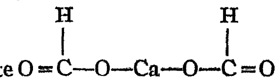
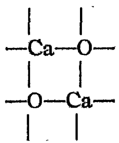
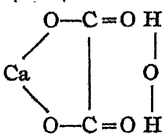
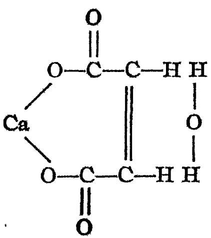
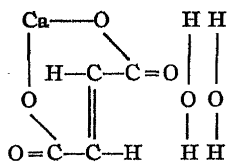


FIG. 1. *Lower figures*, calcium fumarate; *upper figures*, calcium maleate.

TABLE 5.—REFRACTIVITY DATA FOR CALCIUM SALTS

Compound formula		Mol. wt.	Sp. gr.	Mol. vol.	Mean n_D	$\frac{n^2-1}{n^2+2}$	Refractivity, M_D. Obs.	Elements	Structure
Formate		130.1	2.02	64.4	1.510	0.299	19.3	C+O+H=14.4; diff.=Ca=4.9	0
Oxide		56.1	3.31	16.9	1.830	0.439	7.4	Ca+O=7.1	0.3
Oxalate		146.1	2.23	65.5	1.564	0.325	21.3	Ca+C+O+H=20.8	0.5
Maleate		172.1	1.84	93.5	1.571	0.329	30.8	Ca+C+O+H=27.8	3.0
Fumarate		190.1	1.71	111.2	1.539	0.313	34.8	Ca+C+O+H=31.5	3.3

refraction weaker. It appears under the microscope in rods or fragments, with the indices: $\alpha = 1.495$, $\beta = 1.580$, $\gamma = 1.640$, all ± 0.003, making the double refraction 0.145. The axial angle $2V$ is calculated to be $77°36'$, and $2E$ $164°$; this is too great an angle to be determined by the immersion method. The orientation is $X = c$, $Y = a$, and $Z = b$, so, as in the case of the fumarate, the longer crystal axes do not correspond to the lesser refractive indices. The mean $n = 1.571$ gives, on the same basis as before, the refractivity 30.8.

DISCUSSION OF THE REFRACTIVITY DATA

The refractivities of the elements other than calcium used are those of Eisenlohr:[4] $C = 2.4$, $O{=} = 2.2$, $—O— = 1.5$, and $\mathrm{H} = 1.1$. In calcium formate two entirely separate acid radicles are present, so the difference between the total refractivity and that calculated for the elements of the radicle may be regarded as the normal value for calcium. It is 4.9.

In calcium oxide X-ray study has shown the atoms to be arranged as shown, with directions of attraction (electrostatic) also perpendicular to the paper. This represents but little strain, and the additional refractivity due to the structure is slight. In the oxalate the calcium unites the two ends of the radicle into a ring, and as would be expected this produces a slightly higher extra refractivity.

In calcium maleate a double bond is present, which according to Eisenlohr produces in any case an extra refractivity of 1.0; but in addition the calcium unites two ends of the radicle. The ring produced in this case is much larger than that of the oxalate, and the double bond forms part of the ring, so that an additional strain must be represented; and this is seen to produce an excess of refractivity of 2.0.

The most complex of all of the compounds considered is calcium fumarate, which not only has the calcium uniting the ends of the radicle into a ring, but also, because the position of the substituting groups with respect to the double bond, has an irregular ring. Still more excess refractivity than in the maleate would be expected, and as a matter of fact the calculation gives 2.3.

SUMMARY

The preparation and crystallographic-optical properties of calcium fumarate and maleate are described. Both are orthorhombic, but they show no definite space relationships. From a calculation of the

[4] Spektrochemie Organischer Verbindungen, p. 48. 1912.

refractivities it appears that their peculiar structures lead to a definite extra refractivity, greater in the case of the less symmetrical fumarate.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

632D MEETING

The 632d meeting of the Biological Society was held in the auditorium of the National Museum, at 8 p.m., on Jan. 4, 1922, in cooperation with the Audubon Society and the Wild Flower Preservation Society, with President BAILEY in the chair. Mr. STEPHEN T. MATHER, of the National Park Service, introduced the speaker of the evening, Mr. ARTHUR C. PILLSBURY, official photographer of the Yosemite National Park.

Mr. Pillsbury's subject was *Wild flowers and birds of Yosemite National Park*. It was illustrated with moving pictures showing birds, flowers, and scenery of Yosemite Park. A striking feature was the exhibition of some twenty or more series of pictures showing the opening of the buds of as many different kinds of flowers; the exposures were taken at fifteen minute intervals, so that as projected on the screen the opening was accelerated several thousand times.

633D MEETING

The 633d meeting of the Biological Society was held in the lecture hall of the Cosmos Club on Jan. 21, 1922, with President BAILEY in the chair.

The following persons were elected members: Miss LUCY HOWARD, HAROLD M. VARS, HERBERT F. PRYTHERCH, and ARTHUR H. FISHER. The President appointed Messrs. ROHWER, JACKSON, CHAMBLISS, and COKER as a Committee on communications.

Under general notes, Dr. R. W. SHUFELDT exhibited a new biography of the well known British ornithologist ALFRED NEWTON, by WOLLASTON. Dr. SHUFELDT showed lantern slides of Professor Newton from several pictures, also some other slides illustrating the biography.

Mr. HOFFMAN showed a specimen of *Attacus edwardsii*, one of the largest known moths, from India.

Major GOLDMAN reported having attended an organization meeting of the Boston Bird-Banding Society, which recently occurred.

Mr. WILLIAMS reported hundreds of starlings congregating and roosting on the Hughes Building near the Cosmos Club, as many as 400 or 500, he estimated. They seem to chirp all night.

The following program was given:

S. F. HILDEBRAND: *Fish in relation to mosquito control.*

The speaker had been employed in the summer of 1921 to introduce fish into mosquito-breeding waters about Savannah, Ga.

The top minnow, *Gambusia affinis*, is altogether the best fish for introduction, although all small fish will feed on mosquito larvae under favorable conditions. The top minnow is viviparous, hence does not have complicated nesting habits to be taken into consideration. It is a prolific and hardy fish and never outgrows the mosquito-eating size. With the aid of a large number of lantern slides the speaker discussed the effect of various kinds of vegeta-

tion in the water in protecting or screening the larvae from the fish, as well as other factors having an influence upon the matter.

Major GOLDMAN asked if the top minnow could be introduced outside its normal range. The speaker said it has winter-killed in the Mississippi Valley to a considerable extent.

President BAILEY remarked that lily pads are eaten by beavers, and silver grass by muskrats, which would reduce the mosquito protection where these animals occur.

H. L. SHANTZ: *Notes on the white ants of Africa.*

The speaker in his extensive explorations of Central and South Africa had continually come into contact with termite nests, as they are generally conspicuous objects. They tell the color of the soil at a glance. There are many types, which were illustrated with lantern slides, some colored. Where large hills stand a long time and disintegrate, the earth is richer than elsewhere, and natives select such places for cultivation.

Discussed by Mr. ROHWER and Mr. WHITE, who compared the local species about Washington, in their aversion to light, etc. Mr. White said the local species are very beneficial on his farm by eating out stumps, which thus decay much more rapidly; a 4-inch stump is often eaten almost wholly out in a year. They damage apple trees where wounds occur, making a mud tunnel up the bark.

Major GOLDMAN recalled the statement in Drummond's *Tropical Africa*, that termites there perform for the soil a service like that of earthworms in temperate countries, passing the soil through their bodies and enriching it.

Dr. SHUFELDT described the orientation of a true ant at Savannah, with reference to its path.

C. DWIGHT MARSH: *Live stock poisoning by death camas.*

Stockmen on the western stock ranges suffer very heavy losses of sheep from poisonous plants. Probably of all the plants those which cause the greatest destruction are those commonly known as death camas, which are species of the botanical genus *Zygadenus*. Losses of hundreds of sheep within 24 or 48 hours are not at all unusual. These plants have been known to be poisonous for nearly a century, but definite knowledge in regard to their properties has only been acquired within the last 20 or 25 years. The plants poison horses and cattle as well as sheep, but the principal losses have been of sheep.

Death camas grows widely distributed over the ranges from the Rocky Mountains westward.

The U. S. Department of Agriculture has made detailed studies of death camas poisoning, and it was assumed that all forms of the plant were about equally poisonous. Recent studies, however, have brought out important facts in regard to their relative toxicity.

There are four common species of death camas on the western ranges, and it has been found that two are much more poisonous than the others, while one species that has always been considered dangerous has so little toxicity that probably under range conditions it never causes any losses. The most poisonous species is without doubt that growing in Montana and Wyoming. A California species is equally injurious as far as causing sickness is concerned, but produces fewer deaths. The results of the studies made have indicated clearly the comparative danger from these species and have also shown what measures can be taken to avoid losses.

634TH MEETING

The 634th meeting was held at the Cosmos Club on Feb. 4, 1922, with President BAILEY in the chair and 55 persons present.

Under *Brief notes*, Dr. L. O. HOWARD said that he had noticed in the Annals of Tropical Medicine and Parasitology for September 30 last an illustration showing a botfly larva attached to a tapeworm, but there was no reference to it in the text. He wrote to Professor ROBERT NEWSTEAD of the Liverpool School of Tropical Medicine, inquiring about the specimen figured; Professor Newstead consulted with one of the authors of the paper, Professor YORKE, who stated that the larvae were found by him attached to tapeworms *in the stomach of the zebra*. Professor Yorke gave specimens to Professor Newstead, who with great generosity forwarded them to Dr. Howard, who exhibited them to the Society. He said the case, so far as he could ascertain, is unique. Dr. B. H. RANSOM had told him that once, when collecting in Canada, he had put some tapeworms and some Oestrid larvae in the same vial and had later found that the Oestrids had destroyed the tapeworms as specimens. In the present case, however, the larvae became attached to the tapeworms in the zebra's stomach and presumably while both were alive. The tapeworm was identified as *Anoplocephala rhodesiensis* and the bot larva as *Gastrophilus pecorum* variety *zebra* Rod. and Beq.

Dr. T. S. PALMER reported the recent census of the quail in the District of Columbia, made by the police, who had fed the birds during the period of deep snow, the food being furnished by the Audubon Society. The census showed over 100 covies in the District, with a total of approximately 2095 birds.

President BAILEY reported that buffalo bones had been received recently from a cave in Malheur Co., Oregon, east of Malheur Lake, the locality being about 100 miles further west than any other authentic evidence of the occurrence of buffalo heretofore. Indian tradition, however, indicates that they once occurred about 50 miles further west than this cave.

The first paper of the regular program was by SMITH RILEY, on *The Nation's game supply*, and was illustrated.

Dr. SHUFELDT mentioned the antelope as the most difficult animal to protect, as it persists in remaining on the plains. He once killed a mountain buffalo, considerably different from the plains form.

Dr. MARSH said elk are unpopular with stockmen, especially when it happens that they destroy haystacks and the owner is prevented by law from killing them. Major GOLDMAN thought the stockmen could be pacified by feeding the elk in winter so as to protect the cattle range.

The second paper of the evening was by A. H. HOWELL, on *The relationship and distribution of American chipmunks*. The paper was illustrated by skins of the animals, and by lantern slides in the form of maps with shading to show the areas covered by the different forms. There are in the east one species with four subspecies, while in the west there are five species with 57 recognizable subspecies. The western forms climb trees more than the eastern but are not actually arboreal.

Dr. PALMER said the group was universally called ground-squirrels in the early days, the word chipmunk dating only from 1842. The origin of the term he could not explain. He also mentioned that most of the species have been described by members of the Biological Society.

J. M. ALDRICH, *Recording Secretary*.

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ZOOLOGY.—*Greeffiella* (Trichoderma Greeff, 1869; not Trichoderma Steph. 1835). Contributions to a Science of Nematology, XII. N. A. COBB, United States Department of Agriculture.

In 1869, Greeff described an externally peculiar and very interesting small animal form under the name *Trichoderma*. Though it proves in the end to be internally a typical nema, it is only after many years that the fact becomes fully established. The very small size of the species and the fact that the setose cuticle makes it difficult to examine the internal organs, taken together, have delayed a fuller understanding of the internal anatomy.

Opportunity has occurred to reexamine a species of this genus in a living condition, and the results are presented herewith. They serve to establish the view that the genus comprises typical nemas, in no sense transition forms; the genus presents striking relationships to the genus *Desmoscolex*, another typical nema genus whose affinities also have been long obscured in much the same way, but finally cleared up.

The name *Trichoderma* being preempted, it is proposed to commemorate Greeff's original discovery by renaming the genus after him,—Greeffiella. *G. oxycaudata* (Greeff) is retained as the type species.

Greeffiella, nom. nov.

Trichoderma Greeff, Arch. f. Naturg., Berlin, v. 35, bd. 1, 1869. Not *Trichoderma* Steph., 1835, or Swains., 1839.

Greeffiella dasyura n. sp. $\frac{1.5}{3.4} \frac{10.4}{9.6} \frac{13.}{13.} \text{—} \frac{56.}{15.} \text{—} \frac{70.}{9.8} > 0.31^{mm}$ The thin layers of the transparent, colorless, hairy cuticle are traversed by about fifty-six plain transverse annules, easy of resolution, which are not materially altered on the lateral fields. The number of annules corresponds with the number of encircling rows of somatic setae. While there are no wings opposite the lateral fields, wing spaces are faintly indicated by a slight spareness, or absence, of setae near the lateral lines; this however is a faint feature extending only from the neck to the anus, and is perhaps more pronounced on the female than on the male. The contour of the body is crenate, especially toward the head. There appear to be toward thirty small unequal cephalic setae on the front of the head, disposed, apparently, in two closely approximated circlets. These setae average to be about as long as the head is wide

and are apparently too numerous and crowded to permit of any exact order; however, about twelve of the anterior ones are spread outward and forward while all the others spread out more or less backward. These somewhat curved, rather slender, tapering, acute, somewhat stiff cephalic setae are of the same character as the great bulk of the somatic setae. Among the somatic setae however are a few relatively large, hollow, open bristles of another character, resembling the locomotor bristles found on *Draconema, Desmoscolex,* etc. For instance, on the third and eighth annule of the female, and on the second and seventh annule of the male, that is to say in the rows of setae on these annules, there occur subdorsal (on the second and third annules) and dorsally submedian (on the seventh and eighth annules) pairs of spreading tubular open-mouthed setae, or bristles, a little longer than the regular somatic setae. These special setae have extra large bases and are probably connected with glands. The rows of ordinary cervical setae have a fringe of shorter setae in their midst. As before remarked, the somatic setae are in fifty-six or fifty-seven transverse rows,—excluding those on the head, but counting the finely pilose region in front of the spinneret as two annules. See Fig. 3. Passing backward, the setae grow steadily longer from the head to the tail; the posterior ones are about one and one-half times as long as the spinneret, while the anterior ones are somewhat shorter than the spinneret. Back as far as the beginning of the intestine, the rows of setae present minute toothed fringes, accentuating the annules. The conoid neck ends in a rounded, somewhat flattish hemispheroidal head, set off by a narrow, deep and distinct constriction. The lips are amalgamated and fixed. Nothing is known concerning the labial papillae. The pharynx is exceedingly minute and easily overlooked, but is, in fact, a minute, simple, obscure, straight, regular, tubular, closed, unarmed region about one-sixth as wide as the head and twice as long as wide; these measurements include its enclosing pharyngeal tissue. Under ordinary circumstances there is to be seen here only a closed lumen. Passing backward from the pharynx, the oesophagus for a distance two and one-half times as great as the width of the head, is cylindroid; however, it widens slightly,

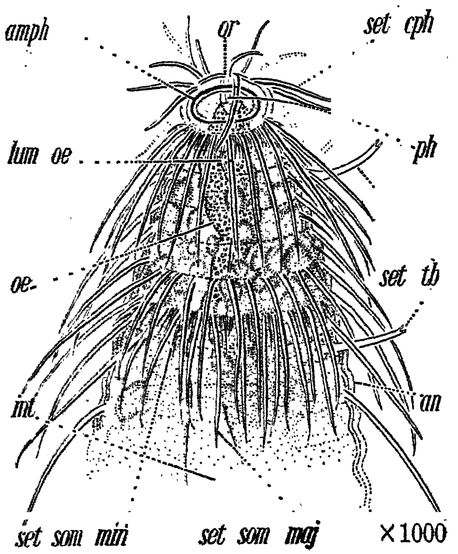

Fig. 1.—Head end of *Greeffiella dasyura.* The setae on several annules immediately behind the head have been omitted so as to show internal details more clearly. *amph,* amphid; *an,* annule; *int,* location of the beginning of the intestine (see also Fig. 2.); *lum oe,* lumen of the oesophagus; *oe,* oesophagus; *or,* mouth opening; *ph,* pharynx; *set cph,* cephalic setae,—a number of which are omitted; *set som maj,* one of the larger somatic setae; *set som min,* one of the smaller somatic setae; *set tb,* tubular seta.

so that it becomes as wide as the head, or one-half as wide as the corresponding portion of the neck, that is to say that portion of the neck marked by the fifth circlet of cervical setae. At this point there is a rather faint diminution of the oesophagus, which continues thence a little narrower, afterward widening out, and then soon coming to contain granules like those found in the cells of the intestine. This latter appears to begin about opposite the tenth row of setae. There are two narrow ducts, one emptying into the posterior part of each amphid; these ducts can be followed backward to near the pigmented bodies soon to be mentioned, and possibly may be connected with them. The external expressions of the amphids, each of which is symmetrical to two lines, are of unequal diameter, without central markings, and are located toward the front of the head; they are about as wide as the corresponding portion of the head, each being about twice as wide as long. The two greenish pigmented bodies mentioned above (org?, Fig. 2), are olive green in color and present a nucleus in the midst of a colorless spherical cell (?) as wide as one of the cuticular annules in the immediate vicinity. These bodies are naturally rather difficult to observe on account of the hairy nature of the cuticle through which they are viewed; they are located well outside the intestine, one on each side of the body, somewhat behind the base of the neck. The broad cardiac constriction lies opposite the eighth to tenth rows of setae, and is about as wide as the distance between these rows. The thick-walled intestine presents a faint lumen and is composed of cells of such a size that about twelve occur in each cross section. In the male, at least, the intestine gradually becomes one-half as wide as the body. There is no pre-rectum. From the minute anus, whose anterior lip is somewhat elevated, the inconspicuous rectum extends inward at right angles to the ventral surface half way across the body; the intestine itself extends past the anus. No anal muscles are to be seen. There are two kinds of colorless granules of variable size to be seen in the cells of the intestine; the largest of these have a diameter equal to the distance between the rows of somatic setae; the finest of the granules are exceedingly fine. The granules are not so arranged as to give rise to a tesselated effect. The more or less convex-conoid tail tapers from in front of the anus to the tubular spinneret, which comprises two-sevenths of the whole

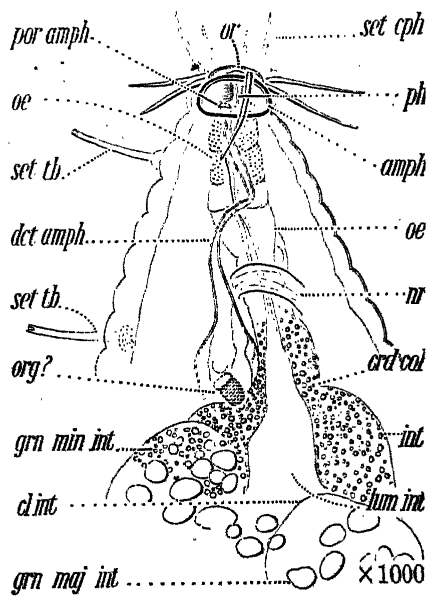

Fig. 2.—Internal anatomy of the head end of *Greeffiella dasyura*. Lettering as in Fig. 1. *cl int*, one of the cells of the intestine; *crd col*, cardiac collum; *dct amph*, duct connecting with the amphidial pore; *grn maj int*, one of the larger intestinal granules; *grn min int*, smaller intestinal granules; *int*, intestine; *lum int*, lumen of the intestine; *nr*, nerve ring; *org ?*, organ of doubtful significance; *set tb*, tubular seta.

tail. This tubular spinneret is about as wide as one of the spicules of the male; it is a simple truncate affair which tapers but very little. A marked peculiarity of the posterior extremity of the nema is the existence of numerous minute setae; for a distance equal to the length of the spinneret the setae on the portion of the tail immediately in front of the spinneret are very much reduced and more numerous. The spherical caudal glands are located behind the anus in the anterior fourth of the tail and empty through separate ducts; each is about one-fifth as wide as the corresponding portion of the tail, or as wide as one of the somatic annules opposite. Only two nuclei were seen in connection with these glands, and these were located in the vicinity of the anus, their number indicating that the number of caudal glands may be less than the usual three. The excretory pore lies near the nerve-ring opposite the sixth annule in the male and opposite the seventh in the female; its spherical ampulla is one-fourth as wide as the corresponding portion of the neck. The nerve-ring surrounds the oesophagus somewhat obliquely where it first diminishes in diameter somewhat behind the middle. In the dorsal side of the neck, opposite the 9–14 rows of setae there are some relatively large organs,—probably two or more finely granular cells. From the somewhat inconspicuous, small, elevated vulva, which is surrounded by minute setae, the small, weak, non-cutinized, tubular vagina leads inward at right angles to the ventral surface about one-third the distance across the body. Little is known concerning the double symmetrically reflexed female sexual organs.

$$\frac{1.5}{3.2}\ \frac{6.6}{7.7}\ \frac{10.6}{11.}\ \frac{'M}{18.}\ \frac{76.}{11.} > 0.34\ \text{mm}$$

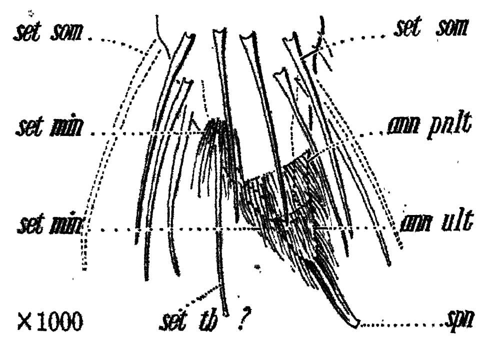

Fig. 3.—Tail end of *Greeffiella dasyura*. Lettering as in Figs. 1 and 2. *ann pnlt*, penultimate annule; *ann ult*, ultimate annule; *spn*, spinneret.

The slightly arcuate, irregularly conoid, faintly sigmoid tail of the male, on the whole, rather resembles that of his mate. The two equal, straight, very slender, uniform, acute, colorless spicula, which are slightly cephalated by expansion, are about one and one-fourth times as long as the anal body diameter. If swung around behind the anus, they would just about reach to the base of the spinneret; they are about twice as wide as the bases of the somatic setae, are a little larger distally than elsewhere, and are perhaps winged. No gubernaculum has been seen. On the fifth and eleventh annules in front of the anus occur ventrally submedian papilla-like organs, indicated by the presence of minute setae arranged in a cluster about a nerve ending (?),—about ten setae on the fifth annule and a much smaller number on the eleventh. There are also similar ventrally sublateral bunches of setae on the annules preceding the large (duplex?) conical one bearing the spinneret. On the lateral field near the middle of the male, a bunch of minute setae was observed like those on the fifth annule in front of the anus. The nature of these special organs, for such they must be, remains in doubt. It seems quite possible that some of them are male supplementary organs. The wide cylindrical testis is one-half as wide as the body and is reflexed to near the proximal ends of the spicula.

Habitat: Found in sponges, Biscayne Bay, Florida, U. S. A., March, 1916. Male examined and measured in a living condition; female fixed in Flemming's solution and soon after examined and measured in water. The form of the pharynx and oesophagus; the presence of special tubular setae; the structure of the spinneret, and the relatively small number of annules, seem to indicate a closer relationship of *Greeffiella* with *Desmoscolex* than has been hitherto imagined. Perhaps *Greeffiella* should be placed in the same family with *Desmoscolex, Tricoma,* etc.

ETHNOLOGY.—*Some new ethnologic data from Louisiana.*[1] DAVID I. BUSHNELL, JR.

The following brief notes were secured by the writer during January and February, 1922, from a woman named Rose Deruisé, who was born near New Orleans January 6, 1834. She claims to be, and probably is, three-fourths Indian, her mother having been a full blood and her father a half blood. The early years of her life were spent at an Indian village a few miles west of New Orleans, situated between the left bank of the Mississippi and the south shore of Lake Pontchartrain, in the northern part of Jefferson Parish, Louisiana. During the Civil War the site of the native settlement was occupied by a Federal camp, known as Parapet camp, and it appears that after the war the settlement no longer existed as it had in earlier years. The following notes record the manners and customs of the people of the native village during the years preceding the war.

It is now difficult to identify the tribe to which my informant belonged. She says that her people often visited the Choctaw who then lived across Lake Pontchartrain, and that all spoke the same language, although in some instances the names of certain objects and of plants and animals differed. This may have been a small detached settlement of the Choctaw and may have occupied the site of a more ancient village of the old Washa tribe after the latter had become scattered. According to Bienville the Washa spoke Chitimacha, but it is possible that remnants of the tribe later adopted the language of the Choctaw. Possibly my informant was descended from some of these, and many of the peculiar customs and ways of life related by her may have been those of the ancient Washa.

Habitations.—Some structures were circular and others rectangular, and in addition to these a sloping single roof was supported by posts—a lean-to which served as shelter from sun and rain. All were thatched

[1] Received June 6, 1922.

on top and sides with palmetto leaves. Mats made of rushes were often used on the inner walls of the more elaborate structures.

In addition to the village which stood a short distance west of New Orleans, the old woman recalled a camp site on the southeast shore of Lake Pontchartrain, about 12 miles northeast of New Orleans, at Petit Bois, or Little Woods. It was here that the Indians stopped when preparing to cross the lake in their canoes, and it was likewise the landing place when they arrived from the opposite shore. Fragmentary pottery, bits of animal bones, etc., discovered in 1916 and 1917, indicated the position of this old camp ground.

Food.—Strips of venison, ducks, etc., were dried or smoked and so preserved for future use. All were first thoroughly cleaned and salted, then strung on cords and suspended between two trees or posts, and a fire kindled on the ground beneath. The warmth and smoke would soon dry the meat. Shrimp were dried in the sun after first being placed in scalding water to harden the meat. Fish were prepared by first being thoroughly cleaned, and after a quantity of salt was rubbed on the flesh they were piled one upon another in a large wooden tray and held down by a heavy weight. In this position they were allowed to remain for ten days or two weeks, during which time they would become quite dry, the moisture being pressed from them. Next they were strung on cords that passed through the tails, the ends of the cords were fastened to trees or posts, and the fish thus suspended were more completely dried and cured by the smoke and heat of small fires kindled on the ground under them.

All vegetables obtainable, such as potatoes and pieces of pumpkins, were boiled in a large pot with rabbits or squirrels, or pieces of meat of any sort.

Filé was prepared by pounding in a wooden mortar the dried leaves of *Sassafras variifolium*.

Leaves of the yaupon (*Ilex vomitoria*) were boiled in water and the liquid was used as a beverage like ordinary tea. The leaves were used either green or dried. Milk was added to the drink when it could be obtained.

The favorite method of preparing corn was to allow the whole grains to remain in water overnight, or until they would swell and the husks become softened and loosened. The husks were then removed and the grains crushed in a wooden mortar to form a thick paste. The paste or crushed grain was later boiled in water and so eaten.

Caches.—Caches were used extensively and every family had one or more. Quantities of dried fish and venison, supplies of various sorts, dressed skins, etc., were deposited in caches, and when so hidden would seldom be found except by their owners. Caches were prepared by making an excavation in dry ground and lining it with a large number of palmetto leaves. The material to be protected was placed in a crude box or wrapped in bark and placed in the pit. More palmetto leaves were then placed on top and they in turn were usually covered with an old blanket or one or more skins. All was then covered with earth or sand and made to resemble the surrounding surface. When the house was occupied similar pits were used to hold the potatoes, hides, and other possessions of the family, but they were not so carefully closed and protected.

Dress and personal decoration.—Tattooing was practiced extensively by the people of two or more generations ago. The skin was pricked with a needle, or with several needles tied together, and the surface thus punctured rubbed with soot which had been mixed with oil or some kind of grease. The women, after marriage, often had a dot tattooed near the corner of the mouth. The hands, arms, and neck were likewise decorated.

Pins, brooches, earrings, and other ornaments were made of silver coins hammered thin, then cut and trimmed to the desired shape and size.

Skin dressing.—Some skins were prepared for various uses without removing the hair or wool. They were stretched in a frame or over some firm surface as soon after being removed from the animal as possible, otherwise they would become hard and dry. When properly stretched, a quantity of dry corn meal was rubbed on the flesh side to absorb all the oil and grease, the surface was scraped with a sharp implement to remove the particles of flesh, more corn meal was rubbed in, and the surface again scraped. Soon the entire skin would become soft and pliable. If it was desired to tan the skin with the hair removed, the latter was first singed with a hot coal or moved quickly over a small flame until it could be rubbed off, then both sides of the skin were treated with corn meal and scraped, as described above. The implement used in scraping the skins resembled a long chisel, made of hard wood and beveled at one end.

Pottery.—Earthenware vessels were made and used for many purposes. Three sorts of clay were known, black or gray, white, and red,

but red was considered the best, as it could be burned hardest. The clay was first mixed with water, only enough being used to make a heavy pasty mass. A quantity of the clay was then pressed over some smooth round object, a gourd of the proper size being preferred. The mold was then removed and the clay carefully worked into shape, being pressed, expanded and thinned, more clay being added as necessary, and the whole mass gradually assumed the desired form. The vessel was allowed to dry slowly in the air. The surfaces were then smoothed by scraping with a shell and incised decorations were added if desired. Neither crushed shell nor sand was mixed with the clay. Tobacco pipes were often made of white clay. The pipes were usually covered with oil or grease before burning, which caused them to turn black. After burning, they were polished. Vessels were likewise made black, and with use acquired a high polish.

The method of burning pottery vessels was this: a hole was made in the ground, the bottom and sides of which were covered with dry grass and bits of bark and wood. The vessels, thoroughly dried, were then placed in the hole and covered with similar grass and bits of bark and wood. This was ignited and lightly covered to cause it to burn slowly. When the fire subsided the earthenware was sufficiently burned.

Mortars and pestles.—Wooden mortars and pestles were made and used for various purposes, especially for crushing corn and preparing filé. The mortars were from 2 to 3 feet high. The cavity was made by burning the wood and chopping away the charred particles. When of the desired size the inner surface was scraped and smoothed and all the burnt wood removed.

Baskets.—Baskets of several forms were made of split cane. Dyes were prepared from roots and barks, but my informant could not remember the names of the roots.

Spoons.—Spoons were made of cow horns and were used extensively. They were called *Mooconá.*

Needles.—Needles 4 inches or more in length were made of dogwood, or other woods if dogwood could not be obtained. The needles were very sharp pointed and perforated to receive the thread, and very good work could be done with them.

Threads.—Threads of sinew were used in sewing skins and for other purposes. They were made of the intestines of various animals, that of the deer being preferred. The threads and larger strands were often

made very long by splicing several pieces and twisting them before they became dry. One end would be fastened to a tree and the line pulled and stretched.

Cords.—Spanish moss, after being properly prepared, was used in making ropes and lighter cords. Some were made by twisting, others by braiding.

Saddles.—Saddles, or pads used as saddles, were made by weaving the soft cords of moss.

Weapons.—Blowguns and bows and arrows were made and used. Blowguns were made of pieces of cane, the perforation being formed by first preparing a long, slender piece of hard wood and forcing it down one end of the cane and then down the other until the entire length was open and clear. Darts were made of pieces of hard pine, worked and smoothed, then tufted with some soft material.

Transportation.—Canoes were made of a single log, cypress being the favorite wood. Canoes, or dugouts, 20 feet in length and 3 feet in width were not uncommon, although much smaller ones were used on the shallow, narrow bayous. The larger canoes were used in crossing Lake Pontchartrain, and when the weather was favorable sails made of one or more deerskins would be raised.

Burials.—The bodies were wrapped in blankets or skins and carefully placed, in an extended position, in graves which had been thickly lined with palmetto leaves. A quantity of similar leaves were placed over the bodies and all was covered with earth or sand.

It is to be regretted that more could not have been learned of the manners and ways of life of the people of this native settlement, which evidently existed until some sixty years ago. Nor is it now possible to give the name of the tribe or tribes to which the people belonged, but it is more than probable they were Muskhogean closely allied with the Choctaw whose villages stood on the northern shore of Lake Pontchartrain.

BOTANY.—*Notes on marsh and aquatic plants of Missouri.*[1] F. P. METCALF, Biological Survey. (Communicated by A. Wetmore.)

During the summer of 1920 the writer was engaged in an extensive survey of the marsh and aquatic plants of Missouri for the Biological Survey, U. S. Department of Agriculture. The results of this work were so interesting from the standpoint of plant distribution that it

[1] Received June 5, 1922.

is thought advisable to make known the most salient features in a preliminary paper.

Ten species of plants collected by the writer had not previously been reported in the State. These are as follows: *Alisma brevipes* Greene; *Hemicarpha aristulata* (Coville) Smyth; *Naias guadalupensis* (Spreng.) Morong; *Nymphoides peltatum* (S. P. Gmel.) Britten & Rendle; *Paspalum plenipilum* Nash; *Potamogeton crispus* L.; *P. friesii* Rupr.; *P. heterophyllus* Schreb.; *Ruppia maritima* L.; *Rynchospora corniculata* (Lam.) A. Gray.

The majority of these plants are from stations that fall well within the range of manuals covering the region, from which they have been omitted, in most cases, from lack of intensive work on the marsh and aquatic flora of the state. *Naias guadalupensis* and *Potamogeton heterophyllus* are good examples of this, as they were found in a number of lakes. Most interesting of all, however, were the plants whose known range did not previously extend into Missouri. Of these there may be mentioned first *Nymphoides peltatum*, formerly known to be naturalized only in the vicinity of Washington, D. C.; an unpublished report for this plant from Louisiana,[2] as well as that of the writer from Missouri, extend its range to the southwest for a considerable distance. Another species, *Potamogeton friesii*, was previously unknown south of Minnesota, Wisconsin and Michigan. The known range of *Alisma brevipes* is extended southeastward, as formerly it was not recorded east of North Dakota, Nebraska and New Mexico, while *Hemicarpha aristulata* was found at the extreme eastern border of its range.

Besides those that have been mentioned, new locality records are given for a few other plants that for the most part are decidedly rare throughout Missouri, where their distribution is inadequately known. In these two categories are: *Eleocharis quadrangulata* (Michx.) Roem. & Schult.; *Panicum bicknellii* Nash.; *Potamogeton amplifolius* Tuckerm.; *P. foliosus* Raf.; *P. pectinatus* L.; *Sagittaria brevirostra* Mackenzie & Bush; *Utricularia minor* L.

Complete data for all plants mentioned, with actual citations of specimens collected, will be found in the subjoined list. It may be well to add that in all cases where the collector is not cited, the plant was collected by the writer. All specimens have been placed in the U. S. National Herbarium at Washington.

A list of the more important local and state floras for Missouri has

[2] See annotated list below.

also been appended among which the *Flora of Missouri* by Tracy (24), the only general catalogue for the state, is now somewhat incomplete and out of date, as it was published in 1885. Among local and county floras those of greatest value are that for Columbia and vicinity by Daniels (8); for Jackson county by Mackenzie and Bush (14); St. Louis and vicinity by Eggert (9), Engelmann (10), Hus (13), and the Engelmann Botanical Club (28). The southeastern counties have been discussed by Bush (4) and Uphof (25). The trees and shrubs are treated by Broadhead (2), Bush (6) and anonymously (29). A few miscellaneous papers of interest have been included in addition to those mentioned.

There is no doubt that the number of new plants here added to the flora of Missouri is small in comparison with those that will be found when extensive general collections are made. The Ozark region of the southwest and the swampy region of the southeast are incompletely known. The latter region may be worked profitably by anyone as it will yield important data bearing on many interesting problems in southern and northern distribution.

LIST OF PLANTS

Alisma brevipes Greene. Not previously recorded from the state. Range here extended southeastward; formerly unknown east of North Dakota, Nebraska and New Mexico. Fairly common in lake near Lake City, Jackson County (No. 1030, September 25, 1920).

Eleocharis quadrangulata (Michx.) Roem. & Schult. This plant was reported (28) from Allenton and Pinks Lake near St. Louis but a recent publication (27) states that these stations as well as that of Dozier (which is represented in the U. S. National Herbarium by a sheet collected by George W. Letterman) have been destroyed by drainage and cultivation. The National Herbarium has three other sheets of this rare plant, one from Paddy's Lake, Oswego County, N. Y., July, 1882, by C. S. Sheldon, and two others from Goose Pond, August 20, 1912, and Pond at the Frisco Shops, September 2, 1912, both near Springfield, Mo., collected by P. C. Standley (Nos. 9042, 9777). The writer found this plant exceedingly abundant in Iron Mountain Lake, Iron County (830, August 9, 1920), where in shallow water it formed a complete band around the whole lake.

Hemicarpha aristulata (Coville) Smyth. Not previously recorded from the state. Rare along the sandy border of Lower Contrary Lake, Buchanan County (1006, September 20, 1920). This represents almost the eastern limit of the range of this plant.

Naias guadalupensis (Spreng.) Morong. Not previously reported from the state which, however, comes within the commonly given general range. Common in Kilarney Lake, Iron County (No. 844, August 8, 1920), Little Bean and Bean Lakes, Platte County (No. 1019, September 22, 1920), and rare in Katy Allen Reservoir, Nevada, Vernon County (No. 969, September 9, 1920), and Loch Lin Lake, St. Louis, St. Louis County (No. 821, August 5, 1920).

Nymphoides peltatum (S. P. Gmel.) Britten & Rendle. Not previously recorded from the state. The U. S. National Herbarium has only four sheets of this rare plant. Two of these from near Washington, D. C., from a station where the plant is now extirpated, are from the only locality mentioned for this plant in the 7th edition of Gray's Manual, and in Britton and Brown's Illustrated Flora. One of these specimens was secured August 7, 1894, by A. Fredholm (No. 637), the other on September 27, 1895, by C. L. Pollard (No. 710). The other two sheets come from Gretna, Louisiana, collected May 12, 1899, by C. R. Ball (No. 378), and a pond near St. Louis, Missouri, collected August 21, 1904, by M. W. Lyon, Jr. The writer found this plant abundant in a small pond in Ironton, Iron County (No. 826, August 9, 1920).

Panicum bicknellii Nash (*P. bushii* Nash). Fairly common near Prairie Lake, Papenville, Bates County (No. 980, September 10, 1920). Collected by B. F. Bush, McDonald County, July 24, 1893 (No. 413) and described as a new species, *P. bushii* by Nash (26); possibly the only other record for the state for this rare plant is that of a specimen from Eagle Rock, in the National Herbarium, also collected by B. F. Bush (No. 3246) on August 14, 1905.

Paspalum plenipilum Nash (*P. praelongum* Nash). Fairly common along border of lake near Cedar Gap, Wright County (No. 915, August 26, 1920); not previously recorded although Missouri comes within the range commonly given. The species is also represented in the U. S. National Herbarium by a single sheet from Missouri taken at Paw Paw Junction, September 4, 1877, by B. F. Bush (No. 213).

Potamogeton amplifolius Tuckerm. Not definitely recorded[3] before from the state, although Missouri comes within the general range commonly given. Common in Gravais Mills Lake, Morgan County (No. 888, August 23, 1920), and rare in Hahatonka Lake, Camden County (No. 929, August 27, 1920); in both cases the lakes were fed by cold springs.

Potamogeton crispus L. Not previously recorded from the state; represented in the U. S. National Herbarium by two sheets from Hatchery Ponds, Neosho, Newton County, May 28, 1903 (deposited by Fish Commission). This plant was also collected by the writer (No. 948, September 6, 1920) from the same locality where it has long been established.

Potamogeton foliosus Raf. Apparently common throughout the state, being recorded or collected from Bell Lake, Boone County (No. 869, August 21, 1920); Gravais Mills Lake, Morgan County (No. 885, August 23, 1920); Seequeeota Lake, Springfield, Green County (No. 935, August 29, 1920); Logan Pond, Billings, Christian County (No. 940, September 4, 1920); Lake near Rich Hill, Bates County (No. 993, September 10, 1920); Bean Lake, Platte County (No. 1020, September 22, 1920); Crescent Lake, Excelsior Springs, Clay County (No. 1057, October 2, 1920) and Cemetery Lake, Macon, Macon County (No. 1080, October 9, 1920). Apparently only known[4] previously from Hiffner's Lake, near Alberton, Jackson County (3), a record undoubtedly based on a sheet in the National Herbarium collected by B. F. Bush (No. 618, July 9, 1896). The National Herbarium also has specimens from Poplar Bluff, July 27, 1892, *H. Eggert*; Turner, Green County, September

[3] Reported by Eggert (9), but it is not definitely stated whether the locality was in Missouri or Illinois.

[4] Reported by Eggert (9) and also anonymously (28) in vicinity of St. Louis, but it is not definitely stated whether the locality was in Missouri or Illinois.

5, 1912, *P. C. Standley* (No. 9845), and Springfield, August 20, 1912, *P. C. Standley* (No. 9061).

Potamogeton friesii Rupr. Fairly common at Hahatonka Lake, Camden County (No. 923, August 27, 1920). This and a specimen collected by J. W. Blankinship in Howells County in 1888 in the U. S. National Herbarium are the only two recorded from the state; both extend the range of this plant southward.

Potamogeton heterophyllus Schreb. Fairly common in Normandy Golf Club Ponds, St. Louis County (Nos. 787–788, July 29, 1920); Loch Lin Lake, St. Louis County (No. 819, August 3, 1920); Kilarney Lake, Iron County (No. 845, August 8, 1920); Iron Mountain Lake, Iron County (No. 842, August 9, 1920); pond near Rolla, Phelps County (No. 853, August 12, 1920), and Bean Lake, Platte County (No. 1018, September 12, 1920). Not previously reported from the state; represented in the National Herbarium by a single sheet, from Goose Pond, Springfield, September 2, 1912, collected by P. C. Standley (No. 9780).

Potamogeton pectinatus L. Fairly common throughout the state, being recorded or collected from Big Creve Coeur Lake, St. Louis County (No. 782, July 27, 1920); Upper Contrary Lake, Buchanan County; Mud Lake, Buchanan County (No. 1011, September 21, 1920); New Made Lake, Buchanan County; Sugar Lake, Platte County; Bean Lake (No. 1017, September 22, 1920), Little Bean and Duck Lakes, Platte County. Previously recorded (28) from Arloe, Meramac Highlands, and Creve Coeur Lake, St. Louis County, and possibly by Eggert (9). There is also one additional specimen in the National Herbarium from Gascondy, July 21, 1914, *W. H. Emig* (No. 223).

Ruppia maritima L. Not previously recorded from the state. Common in Clinton Club Lake, Clinton, Henry County (No. 905, August 24, 1920). Possibly introduced but growing vigorously; establishment of the plant here undoubtedly due to the salinity of the spring flowing into the lake.

Rynchospora corniculata (Lam.) A. Gray. Fairly common along Black River, Fagus, Butler County (No. 691, July 10, 1920). Previously reported only from Butler County by Letterman (24). However, there are in the U. S. National Herbarium specimens from Paw Paw Junction, September 4, 1897, *B. F. Bush* (No. 219); St. Louis, July 27, 1892, *H. Eggert;* and Campbell, September 9, 1910, *B. F. Bush* (No. 6302).

Sagittaria brevirostra Mackenzie & Bush. Common in Cooley Lake, Clay County (Nos. 1043–4, October 1, 1920); this lake is only about 20 miles from the type locality for this rare and interesting plant, at Courtney (17), Jackson County, where it was collected by B. F. Bush (No. 2175) August 14, 1904, and October 10, 1903. A specimen (*Bush* 1917) collected on the latter date is the only sheet in the National Herbarium.

Utricularia minor L. Previously reported from St. Louis by Riehl (24) and East St. Louis, Illinois (28). Rare, only found in Duck Lake, Platte County (No. 1025, September 23, 1920). The National Herbarium has no other specimens from this or adjacent states.

BIBLIOGRAPHY

1. BECK, LEWIS C. *Contributions towards the Botany of the States of Illinois and Missouri.* Amer. Journ. Sci. **10**: 257–264. 1826.

2. BROADHEAD, G. C. *Geographical Description of Certain Trees and Plants in Missouri and Kansas.* Kansas City Review **3**: 608–611. 1879–80.

3. BUSH, FRANK. *Flora of Jackson County.* 1st Edition, Dec., 1882, Independence, Mo.

4. BUSH, B. F. *Notes on a List of Plants collected in Southeastern Missouri in 1893.* Ann. Rep. Mo. Bot. Gard. 5: 139–153. 1894.

5. BUSH, B. F. *Notes on the Mound Flora of Atchison County, Missouri.* Ann. Rep. Mo. Bot. Gard. 6: 121–134. 1895.

6. BUSH, B. F. *The Trees, Shrubs and Vines of Missouri.* Mo. State Hort. Soc. Rep. 37: 353–393. 1895.

7. BUSH, B. F. *Missouri Saxifrages.* Ann. Rep. Mo. Bot. Gard. 20: 138–140. 1909.

8. DANIELS, F. P. *Preliminary oecological study of the native and introduced plants of the vicinity of Columbia, Boone County, Missouri.* Mo. Agric. Exp. Stat. Rep. 1898: 124–156.

9. EGGERT, HENRY. *Catalogue of the Phaenogamus and Vascular Cryptogamous Plants in the vicinity of St. Louis, Missouri.* 1891, St. Louis, Mo.

10. ENGELMANN, GEORGE. *Catalogue of a collection of plants in Illinois and Missouri, by Charles A. Geyer, with critical remarks, etc.* Amer. Journ. Sci. 46: 94–104. 1844.

11. ENGELMANN, GEORGE. *Notes on the Grapevines of Missouri.* Trans. St. Louis Acad. Sci. 1: 660–662. 1856–60.

12. GALLOWAY, B. T. *Grasses of Missouri.* 18th Rep. State Board Agric. Mo. 1885.

13. HUS, HENRI. *An ecological cross section of the Mississippi river in the region of St. Louis, Missouri.* Ann. Rep. Mo. Bot. Gard. 19: 127–258. 1908.

14. MACKENZIE, K. K., assisted by BUSH, B. F., and others. *Manual of the Flora of Jackson County, Mo.* 1902.

15. MACKENZIE, K. K., and BUSH, B. F. *New Plants from Missouri.* Trans. Acad. Sci. St. Louis 12: 79–89. 1902.

16. MACKENZIE, K. K., and BUSH, B. F. *The Lespedezas of Missouri.* Trans. Acad. Sci. St. Louis 12: 11–20. 1902.

17. MACKENZIE, K. K., and BUSH, B. F. *New Plants from Missouri.* Ann. Rep. Mo. Bot. Gard. 16: 102–108. 1905.

18. PALMER, E. J. *Flora of the Grand Falls Chert Barrens.* Trans. Acad. Sci. St. Louis 19: 97–112. 1910.

19. PRICE, S. F. *Some Ferns of the cave region of Stone County, Mo.* Fern Bull. 12: 72–77. 1904.

20. SARGENT, C. S. *Crataegus in Missouri.* Ann. Rep. Mo. Bot. Gard. 19: 35–126. 1908.

21. SARGENT, C. S. *Crataegus in Missouri II.* Ann. Rep. Mo. Bot. Gard. 22: 67–84. 1911.

22. SMITH, JARED G. *A Revision of the North American Species of Sagittaria and Lophotocarpus.* Ann. Rep. Mo. Bot. Gard. 6: 26–74, pls. 29. 1895.

23. STANDLEY, P. C. *Ferns of Greene County, Missouri.* Amer. Fern Journ. 6: 44–51. 1916.

24. TRACY, S. M. *Flora of Missouri.* 18th Rep. State Board Agric. Mo., 1885, and Mo. State Hort. Soc., Rep. for 1885, appendix.

25. UPHOF, J. C. TH. *Ecological relations of plants in Southeastern Missouri.* Amer. Journ. Bot. 9: 1–17. 1922.

26. NASH, GEORGE V. *The dichotomous Panicums.* Bull. Torrey Club 26: 568–581. 1899.

27. ENGELMANN BOTANICAL CLUB (Check List Committee of). *A Preliminary Check List of the Cryptogams and Phanerogams in the vicinity of St. Louis, Missouri.* 1911.

28. (ANONYMOUS.) *Vanished plants of our Local Flora.* Bull. Mo. Bot. Gard. 10: 28–33. 1922.

29. (ANONYMOUS.) *Trees, Shrubs, and Vines of Missouri.* 2nd Ann. Rep., Mo. State Board of Agric., 1866.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

635TH MEETING

The 635th meeting was held at the Cosmos Club on Feb. 18, 1922, with Vice President OBERHOLSER in the chair and 101 persons present. The program was as follows:

ROBERT M. YERKES: *The behavior of monkeys and apes.*

The speaker had spent much of a sabbatical year in California where he had opportunities to study several species of monkeys and one young orang about five years old. He devoted much time to testing the intelligence of the latter and two individuals of different species of monkeys, also making observations of other individuals and species. Apparatus was constructed in such a way that the animal entering a room was confronted with a series of doors, on entering one of which he would obtain food. Part of the doors being open and part closed, it was possible to establish a certain relation between the open doors and the right one, or the one leading to the food. The problem was to see if the animal in a large number of trials would come to perceive the relation, so as to go at once to the right door. Although the monkeys solved some of these problems in less time than the orang, the speaker thought that the latter showed more of the human manner of investigation. A large number of lantern slides made the method clear and furnished many illuminating and some very amusing glimpses of the animals involved.

Dr. T. S. PALMER in discussing the paper pointed out the prime importance of a knowledge of the previous history of the monkey under study, as by cruel treatment they may become totally changed in disposition. The whole bringing up of the animal is involved, if any normal plane of intelligence is to be demonstrated.

Under *Short notes*, Dr. BARTSCH mentioned that for five weeks he has had as a visitor to his feeding pan a Brazilian cardinal. Where it came from is unknown. Among other birds that he is feeding he mentioned about 350 starlings.

Dr. PALMER showed a check list of the birds of Africa, lately completed, and spoke of a cooperative plan by which similar lists for other world regions are being completed.

636TH MEETING

The 636th meeting was held at the Cosmos Club on March 4, 1922, with President VERNON BAILEY in the chair and 64 persons present. LAURENCE M. HUEY, of San Diego, Cal., was elected a member of the Society.

Under the head of *Short notes*, Dr. T. S. PALMER announced that the National Audubon Society has lately received a gift of $200,000 for endowment, making the total endowment $600,000 at the present time. He also called attention to the fact that the governor of New Jersey has lately declared the bobolink a non-insectivorous bird; this reminded the speaker that in earlier times the quail was officially classified in Ohio as a song-bird and in South Carolina the bat was determined to be a migratory bird.

He also read a letter from W. B. ALEXANDER, an Australian ornithologist.

Dr. HOWARD told of the 9th annual meeting of the New Jersey Mosquito

Extermination Association. The organization is thriving and enthusiastic, and has accomplished a great deal in removing from New Jersey the stigma of being the home of the mosquito.

Mr. ALDRICH spoke of recent additions to the knowledge of the peculiar Australian parasitic flies of the genus *Palpostoma*, several specimens of which have lately been received at the National Museum. They attack beetles which are injurious to sugarcane, and have considerable economic importance.

Dr. OBERHOLSER reported that during the recent deep snow many species of birds came about his home near Zoological Park, evidently forced by the snow to search for food in unaccustomed places; they disappeared in two days as the snow went away.

Pres. BAILEY said that while in Southern Arizona last winter he had observed that a certain kind of tuber was eaten by rodents to a notable extent. He brought home samples for identification; they grew while lying on his table in a box, perfectly dry. The plant is *Talinum angustissimum*.

Vice President OBERHOLSER taking the chair, President BAILEY presented a paper on *Raising baby beavers*.

The speaker told of experiments in raising young beavers while studying for the Biological Survey the problems relating to beaver farming. He showed lantern slides of the young taken in Northern Minnesota and Wisconsin and raised from the time when their eyes had just opened until well grown, about three months old,—or until he left there in September. The home habits of the young were described, and the manner in which they took to human ways of life, even to the regulation baby bottle of milk, which they were shown absorbing with great relish. They were most affectionate and lovable pets, adopting their foster parents as fully as they were themselves adopted; crying in real baby fashion when hungry or cold, and sure of having all their wants supplied, night or day. They soon learned to come when called, and though reluctantly would return to their little beaver house on the hill near the cabin. Their great delight was to be rocked to sleep in a soft warm lap, or on a cold night to be wrapped in a blanket and taken into a warm bed, where they would cuddle up close and go to sleep as soon as they had finished their bottle of milk.

Although well covered with deep soft fur, they were sensitive to cold, especially if exposed to cold wind. Slides were shown of some beaver houses with thick walls and warm inner chambers, also of beaver dams and ponds, and some of the mature beavers taken alive for study of habits.

In conclusion Mr. Bailey considered beavers easily raised in captivity, gentle and intelligent, promising well as domestic animals.

Mr. BAILEY resumed the chair and Mr. A. S. HITCHCOCK gave the second paper of the evening, *Botanical notes from the Orient*.

The speaker had made a trip to the Philippines, China and Japan, leaving Washington on April 25, 1921, and returned to the city on Dec. 24. About one-third of the intervening time had been consumed in travel. A month was spent in the vicinity of Manila. In this region Mt. Makiling near Los Banos is the best accessible collecting ground for a botanist. The worst drawback here was the abundance of leeches. Baguio was a good place for grass collecting. Omitting China to save time, the speaker described his experiences in Japan, where he traveled on foot with a native botanist as guide and interpreter, thus having an opportunity to live among the Japanese as foreigners rarely do. Lantern slides were shown to illustrate various places visited

and interesting vegetation. Japan is poor in grasses except bamboos; these however occur in wide variety. The speaker showed various articles made of wood, cocoanut shells, etc.

637TH MEETING

The 637th meeting was held at the Cosmos Club on March 18, 1922, with Pres. BAILEY in the chair and 62 persons present.

Under *Short notes*, Dr. H. M. SMITH showed a photograph of an extraordinary crustacean, the rock lobster or salt water crayfish; the specimen at the National Museum was lately received from Sarasova, Fla. It is 36 inches long, including the antennae, and weighed 12 pounds.

He also showed a map of Iceland from the *Theatrum Orbis Terrarum*, published in London in 1606, the work of Abraham Ortelius. All around the island were drawn sea monsters, which were described in the text, which the speaker read.

Dr. HOLLISTER announced the arrival at the Zoological Park of a giant anteater from South America, and described its habits.

Dr. T. S. PALMER spoke of several birds lately introduced into the United States: a Chinese dove at Los Angeles, and at Tacoma the oriental Bamboo Partridge, of which 300 were brought in at one shipment.

Dr. OBERHOLSER reported that at Polksville, in southeastern Iowa, several thousand wild ducks, mostly mallards, have remained all winter, the inducement being regular feeding with corn. They have become quite tame. The starling, he added, has been imported from Asia into Vancouver Island, and is spreading.

Mr. HITCHCOCK spoke on the membership campaign now in progress.

The first paper of the evening was read by Dr. PAUL BARTSCH, on *American shipworms*.

The shipworm is not a worm at all, but a mollusk, related to the oyster and clam. The speaker gave an account of the structure and life history of these animals, using as his example Gould's Ship-worm, the life history of which was almost completely worked out by Sigerfoos in 1908 at the U. S. Bureau of Fisheries Station at Beaufort, N. C.

There are two types of shipworms in America: one which produces living young, and the other which produces eggs. Gould's shipworm is of the latter type. When the eggs hatch, a free-swimming larva is produced; this leads a pelagic existence for a time, the length of which had not been determined, and then settles down on some piece of wood and begins digging a home for itself. The first tiny puncture is just large enough to admit the minute organism, but is widened and deepened as the animal grows. Some shipworms grow to be four feet or more in length, and as thick as a man's thumb. After the burrow is complete, the end is sealed up with a calcareous lining. In fact the whole burrow has been beautifully glazed after its excavation. The mollusk has now stopped growing, and turns its attention to feeding and reproducing. A single specimen can produce from half a million to three million offspring.

The food of these animals consists, not of wood as generally supposed, but of plankton, which is strained from the water by the gills, and carried by ciliary action to the mouth.

Shipworms are very destructive. The most conspicuous loss suffered in

any American harbor was at San Francisco Bay, or San Pablo and Suisun Bay, its branches, where damage of no less than twenty million dollars was done by Beach's Teredo in 1919–1920. An equal loss is probably sustained annually along our various coasts. At Smith island in Chesapeake Bay a wharf collapsed within a period of three months after it was constructed. Recently attention has been called to the ravages of shipworms in the Panama Canal region, where on the Atlantic is the huge borer known as Reyne's Shipworm which freely attacks greenheart timber, a supposedly immune wood; while a closely related species affects the fresh waters of Miraflores Lake on the opposite side. This is the first fresh-water shipworm known from American waters. Zetek's Shipworm is another destructive Panama kind.

Twenty-eight species were listed by Dr. Bartsch from American waters, with data on distribution and other notes; there are also at least five other species known only from fragmentary specimens.

The speaker showed specimens of various kinds, and wood bored by them. He stated that there are four distinct problems presented:

A. A systematic study which must form the foundation for all other inquiries. This has been attempted in a monograph which Dr. Bartsch now has in press.

B. A study of the range of distribution of the various species and their relative abundance.

C. An examination of the physical oceanographic conditions that determine their distribution.

D. A study of the life histories of the various forms.

The second paper of the evening was *The floral alphabet of the Celts*, by IVAR TIDESTROM.

The speaker sketched the distribution of the Celts from Spain to Ireland, Wales and Western Scotland. He proceeded to show how the names of the letters of their alphabet were taken from the names of trees and shrubs beginning with the same sound, the species selected being those of wide occurrence in the Celtic territory. The letter corresponding to our *b*, for instance, was called beith, the Celtic word for birch; *g* was called gort, the name of ivy; and so on. The speaker referred to some of the folklore of the Celts. At the conclusion Miss E. A. Celander sang a Swedish folk-song based upon an old Celtic tradition.

638TH MEETING

The 638th meeting was held at the Cosmos Club on April 1, 1922 with President VERNON BAILEY in the chair and 69 persons present. HENRY HOYT BARROW, LYNN C. DRAKE, FRANK G. GRIMES, SMITH RILEY, and J. R. SCHRAMM were elected to membership.

The first paper of the evening was *Wild flowers that need protection*, by P. L. RICKER.

The speaker first told of the organization, history and aims of the Wild Flower Preservation Society of America. He then discussed the need of protection for many kinds of wild flowers that are approaching extinction in areas near towns, and showed a large number of colored lantern slides of wild flowers of the region about Washington, with some comments on rarity, danger of pulling up the roots in picking, etc. At the conclusion he distributed some leaflets of the Society.

The second paper of the evening, *Hunting fossil vertebrates in southeastern Arizona* was called for but the speaker, J. W. GIDLEY, was not present.

Reverting to the order of *Short notes*, Dr. SHUFELDT said he had found a method of blocking out undesirable backgrounds by the use of small wedges of rubber, illustrating by lantern slides taken in the National Museum, but provided with new backgrounds of outdoor scenes. He also devised the use of an umbrella in taking pictures of wild flowers in the sun, to get better detail by shading the object during exposure. He showed a copy of a new nature magazine, just started in England, called *Nature Land*, edited by Graham Renshaw, and published in Manchester.

Mr. HITCHCOCK asked information on some points in photographing flowers in nature, which was supplied by Mr. Shoemaker. The main difficulty, he said, is wind. A lens of rather long focus is best.

The president called upon Dr. W. J. HOLLAND, director of the Carnegie Museum in Pittsburgh, for remarks. Dr. HOLLAND responded with a very entertaining account of the circumstances leading up to the discovery of *Diplodocus carnegiei*, an immense fossil reptile, and how he came, with the financial support of Mr. Carnegie, to present plaster casts of the famous skeleton now in Carnegie Museum to several of the largest museums in foreign countries. He also told of the Dinosaur quarry opened on Green River in Utah by his Museum, and how on the opening of the region to settlement it was found necessary to designate as "Dinosaur Monument," and to withhold from entry, eighty acres of land including the quarry.

639TH MEETING

The 639th meeting was held at the Cosmos Club on April 15, 1922, with President BAILEY in the chair. ROBERTO DABBENE, WM. A. DAYTON, GEO. C. HEDGCOCK, ERNEST KNAEBEL, J. PARKER NORRIS, JR., WILSON POPENOE, PAUL G. RUSSELL, ALDEN SAMPSON, and JOSEPH H. WALTON, were elected to membership

R. P. COWLES: *A hydrographic and biological survey of Chesapeake Bay.* The bay is comparatively shallow, with some deep holes along the east shore. The bottom is composed of various materials,—mud, gravel, sand, peat, fuller's earth, clay, and oyster shells. The temperature is warmest at the surface and decreases downward during the warm part of the year, April, June and July and August; in March and September it is about the same at all depths; while in the colder months it is colder at the surface and becomes warmer at greater depths.

The large amount of fresh water meets the salt water of the ocean and mixes only imperfectly, the more saline water being heavier and lying somewhat underneath the fresh water. By means of the current meter it has been found that the surface water may be moving down the Bay while the deeper is moving up in the opposite direction; at other times the surface may be almost stagnant while the deeper portion may be in motion either up or down the Bay. The water has usually a slightly alkaline reaction, but in a few regions it is slightly acid, indicating pollution.

Any or all these physical data may have an important bearing on the distribution and activities of the animals and plants in the Bay.

After describing the various instruments used in making observations, and the many cruises taken by the small government vessel used for several years past, Professor Cowles summarized the practical bearing of the work as follows:

First, an effort has been made to determine the normal biological and physical conditions throughout the year, so that when great mortality of fishes,

oysters, clams, crabs, etc., occurs there will be normal data at hand from which to determine the abnormal conditions that bring about the trouble.

Second, to learn all that is possible concerning the movement of layers of water of different density, different temperatures and different plankton content (fish food value) in the hope that the information may throw light on the migration of fishes and crabs at certain times of the year.

Third, to study especially the fauna of the deep holes which occur in many places.

Fourth, to study the so-called "barren bottoms," at the mouths of rivers.

Fifth, to gather as much information as possible which will bear on the conservation of the fisheries resources of Chesapeake Bay.

In discussion Mr. HITCHCOCK said that in British Guiana there is a tide of several feet for 60 miles up certain rivers, and the mangrove grows up that far, showing that salt water comes up underneath the fresh.

R. W. SHUFELDT: *Observations on the fauna and flora of the District of Columbia.* In the paper, which was illustrated with a large number of excellent lantern slides made by the speaker, a general review of the more common or noted animals and plants was given.

640TH MEETING

The 640th meeting was held at the Cosmos Club on April 29, 1922, with President BAILEY in the chair and 67 persons present. LEE M. HUTCHINS, H. B. HUMPHREY, F. E. KEMPTON, MISS GRACE HOLMES, MISS MARY BRADLEY, and MRS. THEODORE KNAPPEN were elected to membership.

The speaker of the evening, Dr. WM. E. RITTER, of the Scripps Institution for Biological Research, was then introduced by Dr. L. O. HOWARD. Dr. Ritter then addressed the Society on *The usefulness and the peril of the laboratory method in biology.*

The speaker himself had had an extended training some years ago in the best laboratories in existence, and as a university professor he carried on the method in educating a large number of college students, so that he was well prepared to discuss the good points of this educational method. Nevertheless he had come to appreciate very keenly the gulf too often existing between academic science, or more particularly academic biology, and any phase of actual human life. He quoted from Wm. Bateson and L. O. Howard on the same line.

The usefulness of the laboratory he found to be unquestioned in the following matters: (*a*) Phenomena concerning which no positive knowledge whatever can be gained without laboratory studies. (*b*) Phenomena concerning which very little positive knowledge can be gained without a combination of "field" and laboratory studies. (*c*) Phenomena concerning which no positive knowledge whatever can be gained in the laboratory (negative utility of laboratory).

The perils of the laboratory are: (*a*) Laboratory necessarily limited to *samples* of nature; hence (*b*) Laboratory procedure necessarily restricted mostly to *analysis;* and to *deductive* reasoning so far as the interpretation of actual nature is concerned. And (*c*) Necessarily tends to beget *laboratory-mindedness,* and mental and social isolation. (*d*) There is a similarity between *monasticism* in religion and *laboratorism* in science.

He proposed the following steps to remedy the situation: (*a*) Preliminary instruction of all would-be scientists with three-fold end in view: (1) to

help them see that all science is *adaptive;* (2) to secure and strengthen them in *natural-mindedness;* (3) to help them acquire the *mental technique* common to all natural knowledge.

(*b*) Coordination in research and teaching of the analytic and deductive procedure of the laboratory with the synthetic and inductive procedure of the field, by (1) carrying the laboratory method into the field as far as possible; and (2) wider and more fully developed application of the statistical method.

(*c*) Preserve in the investigator consciousness of *interdependence* and human meaning of all special sciences.

At the conclusion of the address, which was received with close attention and high appreciation, Dr. HOWARD called on Professor D. H. CAMPBELL, of Stanford University, to lead the discussion.

Professor CAMPBELL said he agreed with much, but not quite with all, that had been said. Research he thought a legitimate and necessary function of universities; and this would generally involve complex highly specialized laboratory processes, often without any immediate practical aim in view. Research cannot be limited to lines in which the application to human life can be seen at the start. Brief remarks were contributed by Messrs. HITCHCOCK, DOOLITTLE, MANN, SLOSSON, HOWARD, SCHMID, LYON, and ALDRICH.

J. M. ALDRICH, *Recording Secretary.*

ENTOMOLOGICAL SOCIETY

343RD MEETING

The 343rd meeting was held November 3, 1921, at the National Museum, with President WALTON in the chair and 35 members and 4 visitors. New member: CARLO ZEIMET, Bureau of Entomology.

L. L. BUCHANAN: *Coleoptera in bird stomachs.*

In determining the coleopterous food of wild birds it is frequently necessary to identify fragments. In this work the form of the sclerites and the sculpturing of the surface are the best guides, and their determination requires an intimate knowledge of the many groups. Apparently the action of the digestive juice causes marked changes in color so that this is misleading. Very rare species are sometimes found in good condition in the stomachs.

In discussing Mr. BUCHANAN'S paper Mr. ROHWER said that the birds often collect something rare in Hymenoptera but that many of the fragments from the stomach were not in condition to permit positive identification. The determination of these fragments was a good test of one's knowledge of the group and might be treated as a game of skill.

N. E. MCINDOO: *Glandular structure of the abdominal appendages of a termite guest* (Spirachtha).

The staphylinid beetles discussed, about the size of a common pin head, were collected by EMERSON in termite nests in British Guiana and were identified by Mann as two new species. They are most remarkable in that the fat abdomen bends forward and lies directly over the thorax and head, and that the abdomen bears three pairs of large fleshy appendages, whose only function seems to be to furnish a supposedly nutritive food for the termites, which have a habit of licking these appendages. The internal anatomy of the appendages is the most peculiar of any yet described. Each appendage is a thick-walled tube or slender sac, completely filled with blood. Lying in the thick walls are countless gland cells whose inner ends are bathed by the

blood, and whose outer ends are attached to the spongy, inner layer of the integument which serves as a reservoir. The gland cells extract a substance from the blood and store it in the reservoir, from which it passes to the exterior through many tiny pores lying in the outer layer of the integument. Once on the integument, the secretion evidently spreads out in a film over the entire surface of the appendages and abdomen.

This paper was illustrated by two anatomical charts which were explained in detail.

Notes and exhibition of specimens

A. N. CAUDELL exhibited a specimen of a remarkable katydid, the recently described *Inscudderia taxodii* Caudell, which feeds only on cypress in the southeastern United States.

Prof. CARL J. DRAKE spoke of collecting on cypress in Mississippi and Louisiana, stating that certain jassids and tingids confine their attack to this tree.

Mr. ROHWER stated that one of two species of horntails seem to breed only on cypress, and that certain parasites of wood-boring Coleoptera also seem to confine themselves to this tree but are not particular as to the systematic position of their insect hosts.

WM. MIDDLETON stated that he had on October 6, 1921, liberated 20,000 adults of *Schedius kuvanae* Howard in Washington, D. C. This insect is a chalcid egg parasite of the gypsy moth. The liberation was made on some trees along B St., on the north side of the Museum, which had a large number of egg masses of the white-marked tussock moth. The parasite has been found to attack the egg of this moth under laboratory conditions and it is hoped that it will be useful in aiding in controlling it here. This experiment is a part of Dr. HOWARD's plan for getting the utmost possible good from such parasitic insects as are introduced into this country.

S. A. ROHWER said he was glad this liberation of parasites was recorded and hoped that all such liberations would be made matters of record and placed available to all specialists. Unless this is done, the specialist is often puzzled when dealing with distribution of species and often has trouble in making identifications.

As an illustration of the phenomenon of predaceous and parasitic insects confining their attacks to those insects which infest a given plant rather than to a given host species or genus, J. A. HYSLOP discussed the two common species of the genus *Alaus*, *A. oculatus* and *A. myops*. The larvae of both of these beetles are exclusively predaceous, feeding on several species of wood-boring larvae, but, despite the fact that they are not wood feeders, *A. oculatus* is always found in deciduous trees and *A. myops* invariably in conifers.

Dr. A. C. BAKER reported the results of some rearing experiments with the apple-grain aphis (the *Aphis avenae* of some American authors). He pointed out that the theory of evolution based on natural selection as propounded by DARWIN has been discarded by most of the experimental workers in zoology. Darwin based his theory on small continuous variations while most of these recent workers pin their faith to discontinuous variations. In the mean time JOHANNSEN established his pure line theory which claims that self-fertilized forms or forms reproducing as in parthenogenesis will remain true showing only fluctuations. Finally LOTSY has recently dispensed altogether with variations. "The cause of evolution lies in the interaction

of two gametes of different constitution." If this were so there could naturally be no true variation in a parthenogenetic line.

EWING had reared the species under discussion for 87 parthenogenetic generations and secured no modifications. His conclusions therefore agree with the usual pure line conception and would tend to support Lotsy's theory. The results obtained here, however, are quite different. There appeared in the parthenogenetic rearings a form which had dropped one entire segment from the antennae. This reproduced true until the winter's frost closed the line. Apterous and winged forms were obtained and even intermediates between these two forms, all lacking the one segment.

We have here then a case where a new form has arisen in a parthenogenetic line—a mutation if you wish. There seems only one way to interpret it. Mutations may arise in pure line parthenogenetic reproduction as well as through the interaction of two different gametes. This granted, Lotsy's theory collapses and the pure line theory as often expressed needs modification.

Micrographs of these forms have been prepared and will in due course be published.

H. S. BARBER reported on the injury to the putting greens of the Columbia Country Club near Chevy Chase, Maryland, by the larvae of the carabid beetle *Agonoderus lineola*. The investigation was made in late August by P. L. RICKER of the Bureau of Plant Industry. The injury was very severe in spots and examination of the contents of the alimentary tract of larvae disclosed chiefly grass roots. Poison baits and sprays apparently were of little value in preventing the damage, and it was recommended that surface fumigation with paradichlorobenzine under tarpaulins be tested.

J. C. BRIDWELL told of the various insects that he had found using as nesting places the galleries of a borer in a rotten stump. *Osmia lignaria* Say was in the fully developed adult stage. Some individuals had been parasitized by *Chrysis* (*Holochrysis*) *hilaris* Dahlb., which had attacked the bee larva after it had spun its cocoon, as was shown by the fact that the *Chrysis* cocoon was always enclosed by the *Osmia* cocoon. Nymphs of the mite genus *Trichotarsus* were associated with these bees. Dead and molded adults of *Typoxylon albopilosum* Fox were found in nests in the pupal chambers, and other cells filled with spiders certainly stored by this species. The nesting habits of this *Trypoxylon* heretofore have been unknown. Other pupal chambers contained the remains of the cockroach *Parcoblatta pennsylvanica* DeGeer, associated with thin silken cocoons thought to be possibly those of one of our two species of *Rhinopsis*, members of a group known to use cockroaches as prey. In branch galleries were cells stored with a large aphid (possibly *Longistigma* according to Dr. Baker), together with cocoons suggested by Mr. Rohwer as possibly those of some Nyssonid. The mite, *Pediculoides ventricosus*, interfered with the rearing of some of the species.

E. R. SASSCER exhibited a base ball, intercepted at quarantine, filled with whole cotton seed.

344TH MEETING

The 344th meeting was held December 1, 1921, at the National Museum, with President WALTON presiding and 33 members and 6 visitors present. Officers for 1922 were elected as follows: *President*, A. B. GAHAN; *First Vice-President*, Dr. ADAM G. BÖVING; *Second Vice-President*, R. A. CUSHMAN; *Recording Secretary*, C. T. GREENE; *Editor*, Dr. A. C. BAKER; *Corresponding*

Secretary-Treasurer, S. A. ROHWER. *Additional members of Executive Committee*, Dr. A. L. QUAINTANCE, A. N. CAUDELL, Dr. J. M. ALDRICH. *Vice President of the Washington Academy of Sciences*, S. A. ROHWER. The program was as follows:

S. HADWEN: *Oestridae.*

This talk consisted of an account, illustrated by specimens and photographs, of the speaker's investigation into the habits and control of the reindeer nose bot fly, *Cephenomyia trompe* L., and the reindeer warble, *Oedemagena tarandi* L.

Notes and exhibition of specimens

Dr. HOWARD, Mr. SCHWARZ, and Mr. CAUDELL gave brief reminiscences of the late Dr. W. H. FOX.

Mr. ROHWER exhibited some letters from the late H. F. BASSETT to Dr. LINTNER and read one relating to one of Dr. Lintner's reports.

C. J. BRIDWELL exhibited the elytra of an *Elodes* on which he has found two eggs of a Tachinid parasite and from which he had removed two larvae of the fly. He commented on the similarity in the method of attachment of the egg to that of the Bruchidae, by a firm cement which gives the larva a good purchase for penetrating the hard elytron, in the same manner as the bruchid larva penetrates the hard shell of the seed.

Dr. ALDRICH was reminded by Mr. Bridwell's remarks of the Tachinid eggs that are sometimes found on the adults of the potato beetle, stating that nothing has ever been reared from these eggs and that they cannot be those of *Doryphorophaga* since this has a piercer and probably deposits its eggs within the host.

Dr. EWING had found these eggs and had succeeded in getting them to hatch, but had never reared the adult fly.

Mr. CAUDELL told of having received specimens of *Zorotypus* from Hawaii and thought it probably a species introduced from the East Indies. He also exhibited specimens of a rare walkingstick-like mantid that Dr. C. J. DRAKE had found in considerable numbers in Mississippi.

Mr. CUSHMAN spoke of the confusion resulting from an old misdetermination of *Habrocracon brevicornis* (Wesmael), whereby the name has long been associated with the common parasite of stored grain insects. The recent rearing of the true *brevicornis* from the European Corn Borer in imported material has been the means of correcting the error.

Mr. GAHAN discussed the habits of a recently discovered parasite of *Diabrotica vittata* adults, *Syrrhizus* n. sp., as given him by the discoverer, Mr. W. V. BALDUFF, of the Ohio State Agricultural Experiment Station. Mr. Gahan outlined the similarities and differences between the habits of this insect and of the common parasite of lady-bird beetles, *Dinocampus terminatus* Nees.

R. A. CUSHMAN, *Recording Secretary.*

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ZOOLOGY.—*New forms of Neotropical birds.*[1] ALEXANDER WETMORE, Biological Survey.

The four subspecies described in the present paper have been noted in the collections of the U. S. National Museum during studies of birds secured by the writer in 1920 and 1921 in southern South America. In the case of the new form of pygmy owl thanks are due Dr. F. M. Chapman of the American Museum of Natural History for the loan of an excellent series of these birds for comparison. The types of the forms here described are all in the U. S. National Museum.

Glaucidium nanum vafrum, subsp. nov.

Characters.—Similar to *Glaucidium nanum nanum* (King)[2] but with dark bars on tail broader (breadth two times or more that of the light bands); slightly larger.

Description.—Type, U. S. Nat. Mus., Cat. No. 284,856, female (in rufescent phase), from Concon, Intendencia of Valparaiso, Chile, collected April 27, 1921, by Alex. Wetmore (orig. No. 6603). Crown, nape and upper back between verona brown and warm sepia; lores, superciliary stripe and streak behind eye white streaked more or less with black; crown and nape faintly streaked and spotted with rather dull cinnamon-buff, the anterior streaks faintly bordered with black; nape with concealed markings of black, white and cinnamon-buff that appear as a broken half collar but that may be arranged to form two distinct eyespots on the back of the neck; streak below eye, including auricular region, blackish slate spotted with white and cinnamon-buff; sides of neck duller than snuff brown, barred and spotted obscurely with cinnamon-buff and, more faintly, with blackish slate; back (save as indicated above) and scapulars, slightly browner than hair brown, the scapulars spotted more or less obscurely with cinnamon-buff, and white bordered by cinnamon-buff; rump and upper tail-coverts verona brown, rump with hidden spots of cinnamon-buff; primaries and secondaries fuscous-black, barred on under surface with white, that becomes marguerite yellow proximally on inner feathers; outer webs of primaries spotted with white, margined with cinnamon-buff; outer webs of secondaries spotted with cinnamon-buff; wing coverts fuscous washed with verona brown; external ones spotted with white, all obscurely spotted with cinnamon-buff; tail fuscous-black, crossed by narrow bars of sayal brown, the dark bars twice the width of the light ones; malar stripe white; chin white with the antrorse hairlike feather tips

[1] Received July 7, 1922.

[2] *Strix nana* King, Zool. Journ. 3: 427. 1827. (Port Famine, Straits of Magellan.)

black; broad band across throat darker than bister, marked irregularly with dull cream-buff; lower fore-neck and upper breast broadly white in center; sides of fore-neck and breast duller than snuff-brown spotted obscurely with cinnamon-buff and white; remainder of underparts dull white streaked somewhat irregularly with bister; sides and flanks wood brown, somewhat mixed with white; tibiae verona brown mixed with cinnamon-buff; tarsi grizzled with white, bister, and cinnamon-buff; under wing coverts fuscous-black mixed with white. Tip of bill deep olive-buff; base puritan gray, shading to deep olive-buff at base, gray clearer on mandible, indistinct on maxilla; iris pale greenish yellow (from fresh specimen).

Measurements.—Males (2 specimens), wing 104.1–106.0, tail 70.0–76.2, culmen from cere (one specimen only) 12.0 mm. Females (2 specimens), wing 110.0–114.0,[3] tail (one specimen) 74.6,[3] culmen from cere (one specimen) 12.5 mm.[3]

Range.—Central Chile (known from Santiago, Valparaiso, Rio Blanco (altitude 1470 metres), and Tofo, sixty miles north of Coquimbo).

Remarks.—The present form, a northern race of *Glaucidium nanum*, may be expected to range northward through the Andes into Bolivia, and perhaps farther. Specimens from Temuco, Chile, near the border of the forest belt, and from the Andes in Chubut, are intermediate between *nanum* and *vafrum* but seem nearer the former. True *nanum*, from the material at hand therefore may be said to extend northward through the humid forest belt of south Chile and the southern Andes, and to be replaced beyond that point by *vafrum*.

Six skins representing *vafrum* have been examined, a male, and one marked female, doubtfully so since the wing measures only 103.7 mm. (not included in the measurements given above) from Santiago, a female from Concon, one with sex not marked from Valparaiso, a questionable male from an altitude of 1470 metres on the Rio Blanco, and a female from Tofo, sixty miles north of Coquimbo. Five specimens of *nanum*, from near the type locality in the vicinity of the Straits of Magellan (Punta Arenas, Laredo Bay and Tierra del Fuego), all agree in having the light and dark bands on the tail of about equal width. The dark tail bands in specimens from farther north become slightly broader, but even those from as far north as Temuco in Chile and northern Chubut in Argentina agree best with *nanum*. It may be noted that Scott and Sharpe (Princeton Univ. Exp. Patagonia, 2[4]: 708. *f. 360.* 1915) figure *nanum* from Punta Arenas with a narrow tail band, as does Crawshay (Birds of Tierra del Fuego, *pl. 35.* 1907) in the case of a bird from Tierra del Fuego, and Koslowsky (El Hornero 1: *pl. III.* Sept. 1919) in one from north of Lago Buenos Aires, Santa Cruz. In all I have examined 16 specimens that may be referred to *nanum* and 6 that represent *vafrum*.

There is considerable uncertainty as to whether *nanum* should be maintained as a distinct species or whether both *nanum* and *vafrum* should be placed as subspecies of *brasilianum*. The distinctions between the subspecies that compose *brasilianum* and the two into which *nanum* is divided

[3] Type.

are purely those of depth of coloration. Collectively the *nanum* group is darker and somewhat more heavily marked than the *brasilianum* group, while the two are complementary in range. Examination of specimens from intermediate localities may easily demonstrate intergradation.

So far as I can determine none of the names that have been proposed for pigmy owls can be referred to the subspecies here described as new. *Athene leucolaima* Bonaparte,[4] said to have come from "Oceania," is based on figures 2 and 3 on plate 4 of the atlas of Zoology of D'Urville's Voyage au Pole Sud. In Volume 3, page 55, of this work, Hombron and Jacquinot state that their specimens came from the Straits of Magellan, as is indicated by the narrowness of the dark bars on the tail. Bonaparte's name therefore is a synonym of *nanum*. The status of other names involved is so clear that discussion of them is unnecessary.

Chloroceryle americana croteta, subsp. nov.

Characters.—Similar to *Chloroceryle americana americana* (Gmelin),[5] but bill broader and heavier.

Description.—Type, U. S. Nat. Mus., Cat. No. 75019, adult male, from the Island of Tobago, collected by F. A. Ober. Hind neck, sides of head and back, rump, upper tail-coverts, wing coverts and outer webs of primaries and secondaries dusky yellowish green with a distinct sheen, becoming dusky olive-green on the crown and forehead; a half collar of white around hind neck; a few white feathers on anterior portion of lower eyelid, and a few minute white markings above the anterior end of eye; secondaries barred with white, and primaries spotted with white on inner webs; scapulars white at base; rectrices dusky bluish green above, black below; three outer rectrices extensively white at base, the white extending farther out on inner webs than on outer, and continued as spots to tip; fourth rectrix spotted with white; throat, submalar region, anterior part of sides of neck, extreme lower breast, abdomen, under tail-coverts and under wing coverts white; lower throat, and breast, save lower portion, between Sanford's brown and auburn; a line from mandibular ramus down side of throat dusky yellowish green; sides, flanks and sides of abdomen spotted heavily with dusky yellowish green; a few spots of the same color on the under tail-coverts; under wing coverts marked with blackish green. Bill, tarsus and toes black (from dried skin).

Measurements.—Males (3 specimens) wing 76.2–78.0 (76.8), tail 51.0–54.5 (53.0), exposed culmen 35.5–38.5 (37.1), tarsus 8.0–8.5 (8.2) mm. Females (2 specimens) wing 76.7–77.5 (77.1), tail 53.0–54.6 (53.8), exposed culmen 36.0–40.0 (38.0), tarsus 8.5–9.0 (8.7)mm. Type (adult male), wing 76.2, tail 53.5, exposed culmen 37.2, tarsus 8.0 mm.

Range.—Islands of Tobago and Trinidad, West Indies; mouth of Orinoco River, Venezuela (?).

Remarks.—The form recognized above is similar in size and coloration to the typical subspecies *C. a. americana* as represented by material from British Guiana, Diamantina (near Santarem) and Ceará, Brazil, save for the markedly stronger and broader bill. *C. a. cabanisi* is larger than *croteta*,

[4] Consp. Gen. Av. 1: 40. 1850.

[5] *Alcedo americana* Gmelin. Syst. Nat. 1: 451. 1788. (Cayenne.)

is paler above and has the white markings on the rectrices more extensive. From *isthmica* the new form is distinguished by smaller size and more extensive rufous brown on the throat.

One specimen in the series of *croteta* examined is marked "Orenoco River, Venezuela," without other designation. The bird in question has the heavy bill characteristic of this form, but as it is a trade skin, secured from the Museum Boucard, the locality is open to doubt.

Dyctiopicus mixtus malleator, subsp. nov.

Characters.—Similar to *Dyctiopicus mixtus mixtus* (Boddaert)[6] but more heavily streaked on entire under surface, with less extensive white markings above, and auricular patch slightly darker.

Description.—Type, U. S. Nat. Mus. Cat. No. 284,616, adult male, from Las Palmas, Chaco, Argentina, collected July 23, 1920, by Alex. Wetmore (orig. No. 4549). Forehead dark drab; crown, nape and upper hind-neck black, feathers of the crown streaked lightly with white, those of nape somewhat elongated, tipped with coral red, forming a patch on either side, more or less confluent at back; antrorse nasal plumes dull white, mixed with black filoplumes; lower hind-neck, back and rump black, barred broadly with white to pale olive-buff, the light areas slightly less in extent than the black; upper tail-coverts black bordered and tipped with large spots of white; primaries and secondaries between hair brown and chaetura drab spotted regularly and extensively with white forming regular bands; secondaries tipped with white; wing coverts black, each feather with a large irregular, sometimes heart-shaped, spot; rectrices black, barred narrowly with pale olive-buff, the bars, passing diagonally across the web toward the shaft; a streak from in front of eye behind rictus to below auricular region, and a superciliary stripe, beginning at front of eye, dull white, the superciliary stripe expanded at sides of nape into a white patch; auricular region forward to eye darker than hair brown, bordered above and behind with black; under surface dull white to pale olive-buff (more or less stained); throat and fore-neck with elongate spots of black; sides of neck and breast with prominent black streaks; sides, abdomen and under tail-coverts spotted and cross-barred heavily and irregularly with black; under wing coverts dull white, spotted with black. Maxilla dark neutral gray; mandible deep mouse gray with mandibular rami slate-gray; tarsus and toes blackish slate (from dried skin).

Measurements.—Male, one specimen (type), wing 87.4, tail 48.5, exposed culmen 19.6, tarsus 18.5 mm. Females, three specimens, wing 82.3–86.6 (84.9), tail 45–55 (49.3), exposed culmen 16.6–18.0 (17.3),[7] tarsus 17.5–19.0 (18.2) mm.

Range.—Northern Argentina from the Territory of Chaco (Las Palmas) and Tucumán (Tapia), north in the Chaco to northern Paraguay (Puerto Pinasco)

Remarks.—The subspecies described above is represented by a male and a female from Las Palmas, Chaco, a female from Tapia, Tucumán, and a female from Kilometre 80, west of Puerto Pinasco, Paraguay. It is distinguished from the typical form from Buenos Aires (represented by four

[6] *Picus mixtus* Boddaert, Tabl. Plan. Enl. 47. 1783. (Buenos Aires.)

[7] From two specimens.

skins from Conchitas and Quilmes), the type locality according to Hellmayr,[8] by the heavier, more decided streaking of the ventral surface and the reduction of the white markings on the back. Smaller bill and darker coloration distinguish *malleator* from *D. m. berlepschi* Hellmayr.

Picus maculatus Viellot,[9] based on the *Carpintero chorreado* of Azara refers to the subspecies described here but is antedated by *Picus maculatus* Scopoli[10] applied to another species of woodpecker. Other names in the synonymy of *mixtus* species refer to other forms.

Myrmorchilus strigilatus suspicax, subsp. nov.

Characters.—Similar to *Myrmorchilus strigilatus strigilatus* (Wied)[11] but male with sides, flanks and under tail-coverts between cinnamon-buff and clay color; superciliary stripe duller, not terminating in a distinct white spot posteriorly; post ocular space slightly darker than bister. Female with under tail-coverts more buffy; superciliary stripe and auricular region duller, less whitish.

Description.—Type, U. S. Nat. Mus., Cat. No. 283,862, male adult, from the Riacho Pilaga, near Kilometre 182 (Ferrocarril del Estado), Gobernación de Formosa, Argentina, collected August 11, 1920, by Alex. Wetmore (orig. No. 4712). Crown and nape streaked narrowly with dull black and cinnamon-brown, the feathers dark centrally and paler laterally, those on nape with a faint buff margin; superciliary stripe dull white, becoming buffy above eye and merging behind eye with buff on sides of nape; a line from the nasal fossa to eye, continued in a narrow line around eye, black, mixed slightly with white behind nostrils and interrupted by a small white spot near center of upper and lower eyelids; malar stripe white; band behind eye slightly darker than bister; auricular region snuff brown; upper back mikado brown streaked broadly with black; scapulars black centrally with inner margin russet and outer margin white, washed with cinnamon-buff, the latter forming a prominent light line above wing; sides of breast tawny-olive streaked with black, blending gradually with white of breast; lower back, rump and upper tail-coverts hazel, the lower back streaked broadly with black; primaries and secondaries fuscous, the outer webs washed with cinnamon near middle, and black proximally; tertials black margined broadly with cinnamon to mikado brown; wing coverts black; lesser coverts spotted slightly with white, middle coverts tipped with white, and greater coverts tipped with white shading internally to pinkish buff; primary coverts tipped narrowly with dull white and cinnamon-buff; central pair of rectrices russet; others black, the outer pair with distal half of outer web and tip white, and the others (save the median pair) tipped with the same color; chin, throat, fore-neck and center of upper breast black; sides of upper breast, lower breast and abdomen white; sides, flanks and under tail-coverts between cinnamon-buff and clay color; bend of wing black; under wing coverts white. Bill black, becoming neutral gray at base of mandible; tarsus mouse gray; iris dull brown (from recently killed specimen).

[8] Verhandl. Ornith. Ges. Bayern **12:** 212. 1915.

[9] Nouv. Dict. Hist. Nat. **26:** 19. 1818. (Paraguay.)

[10] Del. Flor. Faun. Insubr. **2:** 89. 1786. (Antigua, Panay.)

[11] *Myiothera strigilata* Wied, Beitr. Naturg. Brasilien **3:** 1064. 1831. (Bahia.)

Measurements.—Males (4 specimens), wing 65.6–66.6 (66.0), tail 56.1–60.6 (58.6), exposed culmen 16.7–17.7 (17.1),[12] tarsus 31.9–33.6 (32.6) mm. Females (3 specimens), wing 61.3–67.4 (63.9), tail 57.5–60.4 (59.2), exposed culmen 16.4–17.2 (16.7), tarsus 31.5–32.0 (31.7) mm. Type (adult male) wing 66.6, tail 60.0, exposed culmen 17.7, tarsus 31.9 mm.

Range.—Formosa (Riacho Pilaga), Rio Vermejo, and eastern Salta (?) Argentina.

Remarks.—The material on which the form described above is based has been compared with two specimens (male and female) from Bahia, the type locality of *Myiothera strigilata* of Wied. The male of *M. s. strigilatus* has the white superciliary prolonged to terminate in a prominent white spot on the side of the head, and the feathers behind the eye (above the auricular region) almost black. In addition the sides, flanks and under tail-coverts are white with very little buffy tinge. The female of typical *strigilatus* is whiter on the sides, flanks and under tail-coverts, has the superciliary stripe whiter and more prominent, and the side of the head paler. Measurements (in millimeters) of the two skins from Bahia are as follows: male, wing 64.5, tail 57.0, exposed culmen 15.5, tarsus 30.5; female, wing 61.0, tail 52.2, exposed culmen 14.0, tarsus 29.3. It will be noted that in *suspicax* the bill and tarsus seem to average slightly longer than in typical *strigilatus*.

In addition to seven specimens taken by the writer at the type locality, there is a skin in the National Museum secured by Page on the Rio Vermejo, apparently the most southern point from which the bird is recorded, since in Argentina published records indicate it as known only from eastern Salta. No specimens have been seen from the latter locality.

BOTANY.—*The two species of deerhorn cactus.*[1] N. L. BRITTON and J. N. ROSE.

In our southwestern deserts, ranging from western Texas to southeastern Arizona and extending into northern Mexico, just how far we do not know, the well-known deerhorn cactus is to be found. It is never abundant, usually growing up through other bushes with its branches often looking like dead sticks. It has an enormous turnip-like root, sometimes weighing 60 pounds. When in flower it is greatly sought after by plant-lovers. It is a night-bloomer and in the southwest is known as the Queen of the Night. When barren, the plant is difficult to find, but when in flower it can easily be located in the dark by its strong but delightful odor, and people often go into the desert seeking it, carrying lanterns not to aid in finding the flowers but only to guide them away from the thorny vegetation. The plant was long known as *Cereus greggii*, having been so-named by

[12] Average of three specimens.

[1] Received July 18, 1922.

Dr. George Engelmann for Joseph Gregg, a well-known collector of plants, but on account of its peculiar habit, flowers, fruit and seeds, it was made the type of a new genus, *Peniocereus*, by Britton and Rose in 1909.[2]

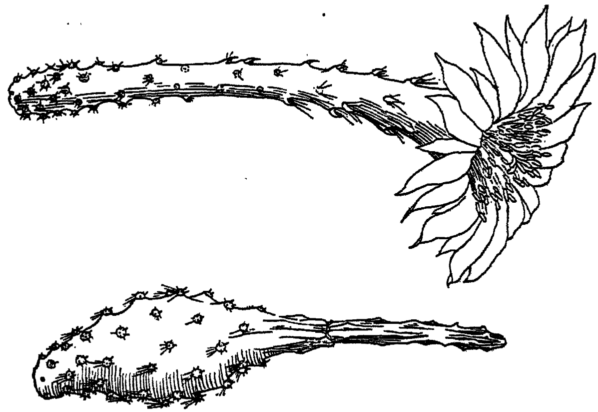

Fig. 1. *Peniocereus greggii.—Upper figure,* flower; *lower figure,* fruit.

In 1921, through the efforts of Dr. B. W. Evermann, a scientific expedition was sent out by the California Academy of Sciences to explore the islands in the Gulf of California. While engaged in the botanical work of this expedition Mr. Ivan M. Johnston collected a second species of this genus which is described as follows:

Peniocereus johnstonii Britton and Rose, sp. nov.

A climbing or clambering plant, up to 3 meters long, with a very large fleshy root, sometimes weighing 14 pounds; stems and branches 3 to 5-angled, the young growth not pubescent; spines 9 to 12, brown to black, glabrous; upper radial spines short, stubby, swollen at base, nearly black, the two lower light brown, elongated, bristle-like, reflexed; central spines 1 to 3, subulate, 4 to 8 mm. long; flower (only an old flower seen) about 15 cm. long; perianth-segments about 3 cm. long; lower and outer perianth-segments bearing tawny hairs and long bristles; flower-tube slender, with prominent areoles on knobby projections and bearing tawny wool and bristly spines; fruit ovoid to oblong, about 6 cm. long, bearing prominent clusters of black spines, dry (?), many-seeded; seeds oblong, 3 mm. long or more, black, shining; seedling dark purple; cotyledons very thick, triangular.

Collected by Ivan M. Johnston on San Josef Island, off the west coast of southern Lower California, May 28, 1921 (no. 3940, type) and June 10, 1921 (no. 4085); also on the mainland at San Nicholas Bay, Lower California, May 16, 1921 (no. 3737).

This species was always found growing up through bushes of *Olneya.*

[2] Contr. U. S. Nat. Herb. **12**: 423. 1909; BRITTON and ROSE, *Cactaceae* **2**: 112. 1920.

KEY TO THE SPECIES OF PENIOCEREUS

Young growth pubescent; areoles on flower-tube not borne on knobs; fruit bearing small inconspicuous spine-clusters; seeds dull black .... 1. *P. greggii.*

Young growth glabrous; areoles on flower-tube borne on knobs; fruit bearing large clusters of spines at the areoles; seeds larger than in the last, shining black .... 2. *P. johnstonii.*

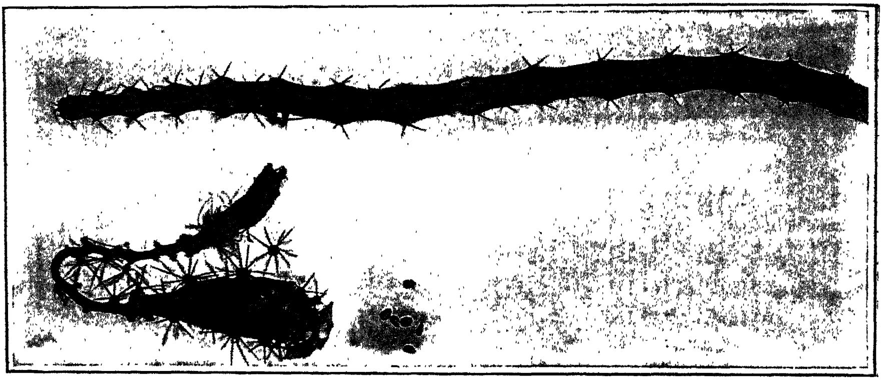

Fig. 2. *Peniocereus johnstonii.—Upper figure,* branch: *lower figures,* old flower and seeds.

BOTANY.—*Three new species of* Passiflora *from Venezuela and Ecuador.*[1] E. P. KILLIP, U. S. National Museum. (Communicated by WILLIAM R. MAXON.)

Recent botanical exploration in Venezuela and Ecuador has brought to light three new species of *Passiflora,* which are described herewith. One of them, *P. popenovii,* is cultivated for its edible fruit.

Passiflora (*Granadilla*) **dispar** Killip, sp. nov.

Stem terete, striate, glabrous; stipules ovate, 2 cm. long, 0.6 to 0.8 cm. broad, foliaceous, serrulate, aristulate; petioles 3 to 3.5 cm. long, bearing 4 to 6 stipitate glands 1.8 mm. in length; leaves ovate, 11 to 13 cm. long, 6 to 7 cm. broad, unlobed or occasionally with one lateral lobe, narrowed to an obtuse apex, subpeltate about 2 mm. above base, glabrate above, densely grayish-tomentulose beneath, palmately 5 or 7-nerved with prominulous secondary veins, reticulate, the margin entire or remotely and minutely serrulate toward the base; peduncles 2 to 2.5 cm. long; bracts ovate-lanceolate, 1 to 1.5 cm. long, 0.5 to 0.6 cm. broad, foliaceous, acute, closely callous-serrulate, the base cordate with unequal lobes; flowers 4.5 to 5.5 cm. wide; sepals ovate-lanceolate, obtuse, 2 to 2.2 cm. long, 1 cm. broad, short-horned just below apex; filaments of faucial corona in several series, the outer filiform, equaling the petals, the succeeding series capillary, barely 3 mm. high; middle corona membranous, erect, irregularly lacerate; basal corona closely

[1] Published by permission of the Secretary of the Smithsonian Institution. Received July 19, 1922.

surrounding base of gynophore, slightly folded, crenulate; gynophore 1 cm. long, glabrous; anthers linear-oblong, 7 mm. long, 2 mm. broad; ovary ellipsoidal, glabrous, glaucous; styles filiform, 6 to 7 mm. long; stigmas orbicular.

Type in the U. S. National Herbarium, no. 1,065,083, collected in forest at Guaremales, along road from Puerto Cabello to San Felipe, Carabobo, Venezuela, altitude 10 to 100 meters, May 20 to June 10, 1920, by H. Pittier (no. 8854).

This species is allied to *Passiflora gritensis* Karst. of the highlands of Venezuela, which is known to the writer only from description. In *P. gritensis* the leaves are deeply 3-parted, the divisions being acute and mucronate, and the peduncles are twice as long as the leaves. The unusual character of the bracts seems to be common to both species. Detailed description of the structure of the coronae of *P. gritensis* is lacking.

Passiflora (*Granadilla*) **perlobata** Killip, sp. nov.

Stem terete, striate, glabrous; tendrils stout, glabrous, up to 10 cm. long (in contraction); stipules narrowly linear-subulate, falcate, 8 to 9 mm. long, 1 mm. broad at base, glabrous; petioles flattened, sulcate, glabrous, 3 to 3.5 cm. long, biglandular about 8 mm. from base, the glands sessile, saucer-shaped, 1.5 mm. in diameter; leaves suborbicular in outline, 6.5 to 7 cm. long, 9 to 10 cm. broad, palmately 5 (or 7?)-lobed to within 1 cm. of base (lobes oblong, obtuse, mucronate, the apical one 6.5 cm. long, 2.5 to 3 cm. wide, abruptly narrowed at base to a width of 4 mm., the two middle lobes 4 to 4.5 cm. long, 2.5 cm. wide, narrowed at base to a width of 7 mm., the two lower lobes 2 to 2.2 cm. long, 1 to 1.3 cm. broad), cordate at base, membranous, glabrous, dark green above, paler beneath; peduncles stout, terete, 5.5 to 6 cm. long, 2 mm. in diameter; bracts free to the base, ovate, 3.5 cm. long, 2 to 2.5 cm. broad, obtuse, minutely tomentulose on both surfaces, the margin entire, becoming involute in drying, biglandular on each side near the base, the glands orbicular, 1 mm. in diameter, black, shining; flowers 8 to 10 cm. wide; sepals oblong-lanceolate, obtuse, 4 cm. long, 1.5 cm. broad, subcoriaceous, apparently green without, white within, keeled on the outer surface, the keel terminating in an awn 2.5 mm. long; petals linear-lanceolate or spatulate, 3 cm. long, 0.8 to 1 cm. broad, obtuse, membranous, rose-colored; filaments of faucial corona in several series, those of the outer ligulate, long-tapering, 2 to 2.5 cm. long, dark blue, banded with white, those of the next series linear, 3 mm. long, white at base, those of the succeeding 3 or 4 series capillary, 1.5 to 2 mm. long, pale blue and white; middle corona membranous at base, filamentose above, the filaments very numerous, 8 to 9 mm. long, spatulate, white below, blue at apex; basal corona annular, 1.5 mm. from base of gynophore; gynophore 9 mm. long, glabrous, sulcate, 2 to 3 mm. in diameter, swollen near base to a diameter of 4.5 mm.; ovary globose, glabrous.

Type in the U. S. National Herbarium, no. 1,067,545, collected at San Antonio, San Cristóbal, Venezuela, July, 1920, by Eleazar Vivas (no. 6).

This species has no very close affinities. Its deeply lobed leaves resemble those of *Passiflora coerulea*, but its linear stipules and more slender, rose-colored petals and the longer filaments of the middle corona readily distinguish it from that species. In the notes which accompany the type speci-

men the collector states that the leaves are 7-lobed. The two leaves which the specimen bears are but 5-lobed. Doubtless the lower leaves have an additional pair of lobes.

Passiflora (*Granadilla*) **popenovii** Killip, sp. nov.

Vine, up to 8 meters in length, glabrous throughout, except the ovary and outer surface of the flower tube; stem terete below, 4 or 5-angled above, striate; tendrils wiry, up to 0.8 mm. in diameter; stipules narrowly linear-subulate, 1 cm. long, 0.5 mm. broad, deciduous; petioles slender, averaging 2 cm. in length, slightly tortuose toward the base, glandless; leaves oblong-ovate or elliptic-ovate, 8.5 to 14.5 cm. long, 4 to 7 cm. wide, acuminate, rounded at base, entire, papery or pergamentaceous, lustrous on both surfaces, featherveined (lateral veins 4 or 5 pairs) and prominulous-reticulate, without ocellae; peduncles slender, elongate, 8 to 10 cm. long; bracts distinct to base, concave, 2 to 2.5 cm. long, 1.2 to 1.5 cm. broad, rounded and often cleft at apex, narrowed at base, entire, minutely puberulent on the lower part of the outer surface; flowers showy, fragrant, up to 10 cm. wide; the tube 1.2 cm. long; sepals deep rose-colored, oblong, 3 to 3.5 cm. long, 1.5 to 2 cm. broad, slightly concave, wide-spreading when developed, obtuse, keeled on the outer surface, the keel terminating in a cusp 3 mm. long; petals white, linear-oblong, 3 to 3.5 cm. long, averaging 1 cm. wide, flat, slightly reflexed; filaments of faucial corona in 4 series, the 2 outer at throat of tube, white, banded with purplish-blue, the 2 inner 3 mm. and 2 mm. from the throat, the filaments of the outermost series filiform, 1.5 cm. long, 1 mm. thick at base, slightly divaricate, those of second series ligulate, fleshy, 3 to 3.5 cm. long, 2 to 2.5 mm. wide, those of third series capillary, 1 mm. long, those of the fourth series capillary, 2 mm. long; middle corona membranous, 5 mm. long, the lower half adnate to the floor of the flower tube, the upper half free, slightly recurved; basal corona none; gynophore stout, grooved, conspicuously swollen about 1 cm. above base; ovary globose, narrowed at base, densely tomentellous; styles clavate, 6 mm. long; stigmas 3 mm. in diameter.

Type in the U. S. National Herbarium, no. 1,060,000, cultivated in volcanic loam at Baños, Tungurahua, Ecuador, at an altitude of 1,850 meters, collected March 6, 1921, by Wilson Popenoe (no. 1271).

The nearest relative of *P. popenovii* is *P. laurifolia*, widely cultivated in the West Indies under the name water-lemon. The flowers of the two species are very much alike, the coronal structure being practically identical. *Passiflora popenovii* is to be separated, however, by its thinner, more acuminate leaves, by the absence of petiolar glands, and by its more slender and more elongate peduncles.

This species is one of several cultivated in Ecuador under the name of "Granadilla de Quijos" and the edible fruit is commonly on sale in the markets of Baños and Riobamba. It is said to be indigenous on the eastern slopes of the Andes.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

641ST MEETING

The 641st meeting was held at the Cosmos Club on May 13, 1922, with President BAILEY in the chair and 74 persons present. The minutes of the last meeting were read and approved. M. N. POPE and Dr. J. W. ROBERTS were elected members of the Society.

Short Notes

Dr. WHITE exhibited a fossil frog or toad in a remarkable state of preservation. It was taken from some oil shale at Elko, Nevado, and is the property of W. K. SHEELER of that place. The stratum is of Middle Miocene age, overlying beds of lignite. It seems that the development of vegetable growth in the water of that early period gradually resulted in ulmohumic acid accumulation, which apparently stopped bacterial growth and thus the frog was preserved in a medium virtually aseptic.

Mr. ALDRICH said in this connection that the shales of the Green River at the Dinosaur Monument in Utah contain many dipterous larvae which seem certainly to be those of botflies, though no reason can be thought of to account for such large numbers of these flies, now very scarce.

DR. HOWARD asked if Dr. WHITE could conjecture what animal could have been the host of such a quantity of bots. He could not offer a suggestion on the matter, however. But he added the remark that the open quarrying of oil shales on a large scale in the West, which is sure to come before many years, will be a veritable gold mine for the paleontologists.

MISS BOONE reported that she had recently visited Mr. CHAS. T. SIMPSON, formerly of the National Museum staff, at his home in Florida. He has for a long time been engaged in gathering and cultivating on a Florida hammock a large number of Florida and other tropical plants; and lately the city of Miami has adopted his place as a public park, to remain in his care.

Dr. WETMORE stated that bird notes are sometimes very unusual. Near Mt. Vernon a few days ago he heard a small bird singing an unfamiliar song from a position on a telephone wire. On inspection, it proved to be an ovenbird. He said that Mr. MCATEE had noted the same case a year earlier at almost the same place.

The first paper of the evening was by Dr. T. S. PALMER, on the subject *Twenty years of Federal protection of the buffalo.*

The first and only appropriation for the purchase of buffalo ever passed by Congress was approved by President Roosevelt July 1, 1902. It was a provision in the general deficiency bill carrying $15,000 for the purchase of buffalo for the Yellowstone National Park, providing fencing, and maintenance for one year. Under this act 21 buffalo were purchased and established at the park.

In 1902 the total number of buffalo in existence was only about 1750, of which 600 were wood bison in Canada; 200 were in a single herd, the property of Michael Pablo in Montana; 52 belonged to the government, and others in small scattered herds. The only wild buffalo were 22 in the Yellowstone National Park and 5 in Lost Park, Colorado. The government herds included 9 head in the Zoological Park here in Washington.

In 1922 the total number of buffalo in existence is over 10,000 of which 6,000 are in Canada and approximately 4,000 in the United States. The Government now has nine widely separated herds with a total of 1,250 buffalo, as follows:

Two in the east—one in Washington, D. C., in sight of the place where buffalo were first seen by white men in 1612; the other at Pisgah, N. C., not far from where buffalo were first reported in that State about 1730.

Two in the Southwest on the former range of the southern herd—one on the Wichita Game Preserve, the other in Platte National Park, in Oklahoma.

Three in the northern Plains Region, the former range of the northern herd—one at Niobrara Reservation, Nebraska; one on the Wind Cave National Park, South Dakota; and one at Sully Hill, North Dakota.

Two in the Rocky Mountain region—one near Ravalli on the former Flathead Reservation, the former home of the Canadian herd; and the other in the Yellowstone National Park.

Five of these herds are on National Parks—Zoological Park, Platte, Wind Cave, Sully Hill, and Yellowstone; four on National Game Preserves—Wichita, Oklahoma; Pisgah, North Carolina; Niobrara, Nebraska; and the Montana Bison Range.

The number of buffalo now in the government herds (1250) represents about two-thirds of the total number of buffalo living twenty years ago. All but about 130 were born on the reservations. The number of calves born last year was approximately 165.

The biological problems of chief importance are those relating to diseases, life history of the animals, and breeding. Four serious diseases are known to occur—Texas fever, gastro-enteritis, haemorrhagic septicemia, and contagious abortion.

The wide dispersal of the various government herds makes it impossible for any epidemic to entirely exterminate the species in the United States.

The length of life of a buffalo, the normal number of calves, and the normal ratio of the sexes, are still unknown. It is generally known that buffalo begin to breed the third year, and the cows have calves every other year or two years out of three, but how long they continue to breed is still to be determined. There is a record of a cow breeding in her twenty-sixth year, and one on Wichita preserve had a calf at the age of 22. The oldest buffalo on record is in Paris, said to be 31 years old. The oldest members of the government herds are a cow 24 years old on the Wichita Preserve and Kalispel Chief, the leader of the Montana herd, now 20 years old. The "ten-dollar buffalo," which lived in the Zoological Park, was upwards of 20 when he died a few years ago.

At the conclusion of the paper MAJOR SHUFELDT gave reminiscences of hunting buffalo in Montana while in army service; the army expedition of which he was a member used several for meat, which he and others shot.

Mr. ROHWER asked whether the government is doing any experimental work in crossing the buffalo with domestic cattle. Dr. PALMER said it is not, but the Canadian government has taken over some private work and expects to extend it.

Dr. WHITE called attention to the fact that Dr. PALMER had himself played a leading part in securing the establishment of the government herds.

Dr OBERHOLSER took the chair, and President VERNON BAILEY exhibited some wild animals, and at the same time gave an informal talk on *Wild*

animals as pets. The animals shown were all rodents;—the common field mouse in a cage with two types of wheel, both in active use; the small kangaroo rat of Arizona, and others. All these animals the speaker said were very readily tamed and made interesting pets. His primary object in keeping them in cages was to obtain information about their habits in the course of his professional duties, but incidentally he found them very enjoyable.

At the conclusion Mr. SMITH RILEY urged the enlargement of this line of work, in order that the economic status of these obscure little animals may be fully developed.

Dr. HOWARD spoke of a mouse plague in Italy since the war, and Major GOLDMAN mentioned one in France. J. M. ALDRICH, *Recording Secretary*.

ENTOMOLOGICAL SOCIETY

345TH MEETING

The 345th meeting of the Society was held January 5, 1922 at the National Museum, with President GAHAN in the chair and 38 persons present. C. J. HARTLEY and L. B. SMITH elected to the Society.

The paper of the evening was the Presidential Address by W. R. WALTON: *The entomology of English poetry*. It was discussed by Mr. SCHWARZ and Dr. HOWARD.

346TH MEETING

The 346th meeting was held February 2, 1922, at the National Museum, with President GAHAN in the chair and 29 persons present. Mr. ROHWER spoke briefly of a meeting of the Executive Committee at which it was agreed to cut the edition of the present volume of the Society from 500 to 400 copies. WILLIAM T. OWREY and M. D. LEONARD were elected to the Society. The program was as follows:

R. E. SNODGRASS: *The fall web worm* (Hyphantria cunea *Drury*). The paper was in a popular form and was illustrated by drawings in pen and ink and in water colors.

Mr. BUSCK made some remarks on the popular form of the paper. He also spoke of some of the characteristic protective movements of the larvae.

J. S. WADE: *On the entomological publications of the U. S. Government*. The speaker gave a list of the various Government publications relating to entomology, with the number of parts and the dates of each series. He gave a brief outline of the development of the Department of Agriculture, which started in 1836 with the Commissioner of Agriculture as its head. The Division of Entomology started in 1863, with TOWNEND GLOVER as its head.

Dr. WM. BARNES of Decatur, Illinois, spoke briefly, giving some recollections of the Society in its early years, and reminiscences of J. B. SMITH, HENRY EDWARDS and various other old time collectors.

347TH MEETING

The 347th meeting was held March 2, 1922, in Room 43 of the National Museum, with President GAHAN in the chair and 31 persons present. The program of the evening was *Notes and exhibition of specimens*.

Dr. EWING gave an illustrated talk on the *Seasonal history of Proturans*. The females are found in every month of the year and the males from January 1st to the end of February. The best time for collecting is from late September through October. Mr. CAUDELL spoke of finding the Proturans between dead leaves.

Mr. BUSCK gave an outline of his recent five months' trip in the tropics, on a survey of the pink boll worm.

Dr. HOOKER of the Experiment Station Record spoke on the subject *How can abstracts in the Record be made more useful?* There was a discussion by Messrs. HYSLOP, CUSHMAN, SCHWARZ, ROHWER and others.

Mr. CAUDELL exhibited a specimen of the imported Japanese preying mantid *Tenodera sinensis* Sauss., taken in Washington, D. C.

Mr. SCHWARZ exhibited a specimen of a male and female of the curious Calandriid beetle *Cyrtotrachelus longimanus* Fabr. from Mt. Omei, Province Tseschauan, northeast China.

Mr. SASSCER reported the interception at Baltimore, Md., by Mr. C. E. PRINCE, an Inspector of the Federal Horticultural Board, of a box in the possession of a passenger from Brazil containing miscellaneous tree and garden seeds and fifty odd packages of cotton and cotton lint. The cotton seed contained living adults, pupae and larvae of the Pink Boll worm. He also exhibited a string of so-called "Italian Beads" found in mail at San Francisco. The so-called beads were filberts infested with larvae of *Plodia interpunctella* Hbn.

C. T. GREENE exhibited three photographs showing the adult spider parasite fly *Oncodes costatus* Loew, and its eggs.

348TH MEETING

The 348th meeting was held April 6, 1922, at the New National Museum. Vice-President R. A. CUSHMAN presided and 34 persons were present.

Notes and exhibition of specimens

Dr. HOWARD spoke of a note recently published by Dr. Feysand regarding the Hymenopterous parasite *Habrobracon johannseni* Viereck stinging the larva of the potato tuber moth *Phthorimaea opercullella* Zeller after it had spun the cocoon. The parasite afterwards feeds through the oviposition hole.

Mr. CUSHMAN spoke of the feeding of *Calliephialtes*, parasite of the codling moth. They feed at the punctures made by the ovipositor. He described the pumping motion employed by the parasite to bring the juice of the host within its reach.

Dr. ALDRICH said that several species of *Agromyza* puncture the leaf with the ovipositor and suck the juice for nutriment.

Dr. HOWARD brought up the matter of the estimates that have been made of the total number of described species of insects and of the total number of species that exist in the world. A general discussion followed.

Hymenoptera.—Mr. ROHWER had counted sample pages of Dalla Torre's catalogue and considered it would be conservative to consider ten valid names per page for Dalla Torre's catalogue. For the species described since Dalla Torre, Mr. ROHWER used the card catalogue in the National Museum, and after carefully estimating the number of cards he subtracted one-third for generic transfers, synonomy, reference to biology, etc. After completing these estimates he had talked to some of his colleagues and Mr. GAHAN had pointed out that for the Chalcids the estimate was, in his opinion, about two thousand too few. To prove this Mr. GAHAN had estimated the index of the volume of the Genera Insectorum and found it contained about 6500 species. It must be remembered that this volume of the Genera Insectorum contains but very little synonomy and but few species other than those which occur in Dalla Torre's catalogue. Mr. Gahan's estimate for the Chalcidoids

would be 14,633 and would average about six species to a genus. Using the Genera Insectorum for the cuckoo wasps in the same way, Mr. ROHWER thought that his estimate for this group was unnecessarily conservative as judged from the basis of the index, and that there must be at least 1,800 valid names of this group. He pointed out that it was very difficult to determine what was a valid species, but from the standpoint of taxonomic study synonomy made but little difference as for all revisionary work it is important to take all synonyms into account. He noted that according to his estimate the number of described Hymenoptera has practically doubled since Dalla Torre's catalogue and that in addition to this the classification of the Hymenoptera has undergone changes which make it difficult if not impossible, for students to find the names given them in the catalogue. He presented these facts to show the great need for a new catalogue of the Hymenoptera.

Mr. ROHWER closed his remarks by stating that he believed 90,000 would be a conservative estimate for the number of described species of Hymenoptera, and to be conservative he would multiply this by three so as to get a good estimate of the total number of species in the world. This would give a total of 270,000. A table was presented showing the number of species in the various groups.

Diptera. Dr. ALDRICH stated that he based his estimates on the catalogue of the Diptera of the world dated 1902-1910, which represents about nine-sixteenths of the species at this time, or about 44,000 species described. After comparing several genera as to species old and new he estimated that about five times this number would be a fair estimate, or 220,000 species described and undescribed for the world.

Coleoptera.—Mr. BARBER said that comparative figures indicating the number of species of beetles had been hastily gotten together but might offer a basis for an estimate. In regard to the fauna of the United States the very conservative Henshaw list of thirty-seven years ago numbered 9238 species, which was raised to 11,256 by the still very conservative third supplement, appearing ten years later. This number has grown steadily, reaching 18,644 (including the Stylopidae) by the close of 1918, according to the Leng list which reflects a slightly more liberal standard of specific differentiation.

In regard to the world fauna we can at present only compare the number of species listed in certain families in the Gemminger and Harold (Munich) catalogue of about fifty years ago with corresponding families that have been listed in the Junk catalogue within the last twelve years. A table of fifteen families out of more than a hundred usually recognized families of beetles showed an average increase of 151% in about forty-five years. If this is representative of the entire order, the 77,008 species of Coleoptera enumerated in the Munich catalogue should now be increased to about 200,000.

To base an estimate of the existing unknown species upon this estimated figure of the known forms would be mere guesswork and if one's field experience is limited to our own fauna is apt to fall far below the reality. For comparison, the speaker was one of a group of half a dozen active collectors paying special attention to the fauna of Plummer's Island and vicinity (near Washington, D. C.), but their combined efforts covering about ten years recorded only about 1300 species of beetles, while six weeks of collecting by Mr. SCHWARZ and the speaker in the humid forests of Guatemala in 1906 produced about an equal number of species, a large percentage (probably quite 25%) of which were represented only by unique examples, and although

groups were sent for inclusion in the then unpublished parts of the Biologia Centrali-Americana, probably 20% of the species still remain undescribed to this date. He believes that we know less than a tenth of the existing species of beetles.

Mr. FISHER added that the small species of Buprestidae from Malaysia contained about 90% new species. This will also apply to the species of the subfamily Lamiinae of the Cerambycidae. In the material collected in Canal Zone about 75% of the species of the tribe Agrilini, family Buprestidae were new.

Orthoptera.—Mr. ROHWER read a note prepared by Mr. CAUDELL in which he stated that Guenther in 1896 states that in 1830 there were 800 described species in Orthoptera, and in 1881 there were 6,500 species, an annual average increase of about 15%. In 1904 Caudell published an exact account of the Blattidae as 1,684. In Kirby's Synonymic Catalogue, 1904–1910, there were 17,896 species of Orthoptera. With increases since then at 1 % a year, a minimum number would total about 20,500 species.

Drs. BALL and QUAINTANCE discussed the Hemiptera but did not give any estimate in figures.

Mr. BRIDWELL made the following statement:

"I have been very much impressed with the fact that those who have spoken after tropical collecting experience have been much more liberal in their estimates than those who have collected only in the United States. My own experience in Tropical West Africa leads me to think of the tropics as exceedingly rich in species. In Nigeria I paid particular attention to the large conspicuous Braconids easily seen in flight and perhaps thirty species were taken of which only one or two species were represented by more than one or two individuals. It is only rarely the case that a species is abundant in any one place. As yet only the larger insects of the tropics have been taken, those smaller than a medium sized Coccinellid being largely unknown.

"Two remarks about beetles made to me by careful men have stuck in my mind. Dr. Peringuey, Director of the South African Museum, told me that he knew six hundred named South African Tenebrionidae and eight hundred still undescribed. An Australian Coleopterist said that while they had 40,000 Australian beetles in their lists they knew that they had 40,000 more undescribed.

"But 80,000 must be far too small a number for Australian beetles since two-thirds of the continent is still unexplored. A hundred thousand would seem nearer the facts. Malaysia and India together must have as many and the same is probably true of Eurasia and the Mediterranean, Ethiopian Africa, North America and South America.

"It has been borne in on me increasingly that the apparent great discrepancy in numbers between the Coleoptera and each of the major orders of insects is not real and that in time they will each reach much more nearly the numbers of the Coleoptera.

"Mr. ROHWER's estimate of the numbers of the Hymenoptera seems to me far too conservative."

Dr. SNYDER stated that in the Termites there were about 1,000 known species, and this number may double or possibly run to about 5,000 species.

Mr. CUSHMAN stated that in a collection of Oriental Ichneumonidae received from C. F. Baker of the University of the Philippines, together with a few from other sources, he had found about 75 apparently undescribed

species of *Xanthopimpla*, a genus distributed through the Oriental, Australian and Ethiopian regions. The Baker collections were made largely on Luzon and Mindanao, Borneo and Singapore with some from the islands of Basilau and Penang; while from other sources there are several from Formosa and a few from China and Java. There are already slightly in excess of 100 species described. He believed that as careful collecting throughout the range of this genus would at least treble the number of species.

Dr. HOWARD, in closing the discussion, ventured the opinion that, considering the character of the men who had spoken, this discussion was the most important which had been held concerning this greatly mooted matter of the number of species of insects. He believed that the number of species of insects in the world must probably exceed three millions.

Mr. BUSCK announced that the name of the spruce bud moth had been changed. This new name will be published in a forthcoming paper which will also contain a key to the species based on genital characters.

Mr. BRIDWELL reported rearing two individuals of an apparently undescribed species of the Chalcidoid genus *Perilampus* from the nests of the genus *Crabro*, one of them from *Crabro chrysarginus*. This is particularly interesting on account of its bearing upon the biology of this genus, since the manner of their oviposition is unknown. They are known to have a migratory Planidium first stage larvae and have been generally bred as parasites of hymenopterous or dipterous parasites of lepidoptera. This is apparently the first American record of a species as parasites on aculeate hymenoptera. In Europe Gaulle records *Peralampus auratus* Panzer as bred from *Solenius rubicola* and *S. vagus* by Lichtenstein. These are Crabronid wasps closely related to *Crabro chrysarginus*. These Crabronids store their nests with diptera (often flower-inhabiting) and they themselves frequent the flowers as do the insects of Perilampus. The utilization of Crabro as a host adds probability to Harry S. Smith's suggestions that Perilampus may oviposit upon flowers and the planidium be carried by insects to their food.

The planidia had evidently made this entrance into the nests of the Crabro in the fall or summer, but their development was retarded until the host material had been brought into the laboratory. The larvae were first apparent as external parasites upon the prepupal larva in the cocoon.

Mr. BARBER exhibited specimens and photos of males of *Dynastes* displaying intergradient forms between the giant "hercules beetles," $6^1/_2$ inches long, through the middle-sized form named *perseus* by Olivier (1789) to the dwarf form two inches long, known under the name *alcides* Fabr. (1787). Mr. SCHWARZ has previously discussed these forms and published a plate in our Proceedings (Proc. Ent. Soc. Wash. **10**: 70). Recently the speaker examined a series of about 20 specimens from Merida, Venezuela (Solomon Bricino & Sons) which supplies an almost continuously intergrading series between the two extremes. In this series the pair of lateral tubercles on the pronotal horn gradually comes closer to the base as the size diminishes until, in the smallest specimens, they occupy about the same position as in the common North American species *tityus*. A photo of 17 of these beetles arranged according to size was exhibited with a sketch map illustrating the habitats of the various species of *Dynastes* and it was pointed out that the Mexican species, *hyllus* Cher. 1843, may connect with our rather abundant and slightly variable *tityus* Linn. of the Southern States, and also through the plateau of Mexico, with the rather distinct Arizona species known as *granti* Horn.

Two varietal names have been proposed by Prof. F. Campos R. 1920 (Revista del Colegio Nacional Vincente Rocafuerte No. 2, p. 30, figs. 11 b-c 1920), based on the denticles of the cephalic horn, but the differences he indicates by his varietal names *unidentatus* and *bidentatus* appear irregularly among the larger individuals of the species and the varieties seem to be without biological significance. Of the three species described by A. H. Verrill in 1905 and 1906 (Amer. Journ. Sci. IV. **21**: 317) from Dominica, W. I. the first (*D. tricornis*) belongs to the genus *Strategus*, the second (*D. lagaii*) seems to be the extreme depauperate form *alcides* and the third (*D. vulcan* Verrill 1905) appears nearly equivalent to *perseus* Oliv. The description of the fourth species, *argentata* Verrill 1907 (op. cit. **24**: 305–308), appears to be based upon a large and unusually brightly colored specimen of *hercules*.

Mr. ROHWER read a note from C. A. MOSIER of Miami Beach, Fla., who sent in the head of an Orthopteron (*Belocephalus subapterus*) found attached by its powerful jaws to the lip of a cat.

C. T. GREENE exhibited specimens of the immature stages of *Hydrophorus agalma* Wheeler (Dolichopodidae).

Mr. SCHWARZ spoke of a letter from Mr. JOHN SHERMAN Jr., calling his attention to a rare book, "The Coleoptera of Georgia," by Le Conte. It contains lists of Lepidoptera, Birds and Plants, but the lists are not signed.

CHAS. T. GREENE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

At the call of Secretary WALCOTT, a meeting of the scientific staff of the Institution and its branches was held in the Smithsonian Chapel, Tuesday, May 23, to discuss the promotion of research in connection with the Smithsonian Institution. Several interesting research problems which could be advantageously taken up were suggested, together with means for carrying them out. A committee on research was then appointed by the Secretary, consisting of Dr. MERRILL, Chairman; Dr. COVILLE, Dr. FEWKES, Mr. FOWLE, Dr. HOUGH, Mr. NELSON, and Dr. STEJNEGER.

The committee will hear reports by individuals on proposed research projects and consider means for taking them up, and it is hoped that by fall a definite plan of action will be formulated.

At a meeting of the Executive Committee of the Institute for Research in Tropical America held June 3 in the Smithsonian Building it was decided to concentrate the efforts of the Institute on the establishment of a research station in Panama near the Gorgas Memorial Institute which is to be erected in the outskirts of the city of Panama. The members present were THOMAS BARBOUR, Harvard University; H. E. CRAMPTON, Barnard College (representing the New York Academy of Sciences); A. S. HITCHCOCK, Smithsonian Institution; and A. G. RUTHVEN, University of Michigan. Dr. WITMER STONE, Philadelphia Academy of Sciences, was absent on account of sickness.

About sixty members and guests of the Chemical Society took part in an excursion to the Endless Caverns near New Market, Virginia, on June 11. The caves are situated in the Shenandoah limestone, in the western branch of the Shenandoah Valley on the opposite side of Massanutten Mountain from the well-known Luray Caverns.

At the annual dinner of the National Academy of Sciences, held at the Hotel Powhatan on Tuesday evening, April 25, the J. Lawrence Smith medal was bestowed upon Dr. GEORGE P. MERRILL, Head Curator of Geology, in recog-

nition of his work on meteorites. This is a gold medal of the value of $200, from a fund established in 1884 as a reward for "original investigation of meteoric bodies." Because of the rarity of investigators in this field, this medal has not been given since 1888.

The American Meteorological Society held its seventh meeting in Washington on April 26. In addition to members of the Weather Bureau, the meeting was attended by representatives of the Canadian Meteorological Service and the Argentine Weather Service.

The bird collection of the late WILLIAM PALMER, consisting of about 3,000 specimens, bequeathed to the U. S. National Museum in his will, has now been turned over and catalogued in the Division of Birds. This collection is very important on account of the large number of District of Columbia records and for the number of immature and molting specimens it contains, Mr. Palmer having paid especial attention to the study of molt for many years.

The annual field meeting of the Petrologists' Club of Washington was held on May 13, 1922, under the guidance of S. G. GORDON of the Academy of Natural Sciences of Philadelphia and E. T. WHERRY of Washington. The party assembled at Perryville, Maryland, on the preceding evening and began the excursion the following morning by a visit to the granite quarry at Rock Run near Port Deposit, on the Susquehanna River. The party then visited the pegmatite dikes in the serpentine area of northern Cecil County, and studied the cross-section of the mica gneiss and phyllite along the Susquehanna from Bald Friar, Maryland, to Peach Bottom, Pennsylvania. Problems of special interest on this part of the trip were the manner of intrusion of the narrow vertical diabase dike in the gneiss near Haines, and the question as to whether the gneiss is the metamorphosed equivalent of the Martinsburg shale or represents a formation of much earlier age.

This was the third annual field meeting of the Club. The first excursion was held on May 18, 1920, when the Club examined the weathering of granite at the Tilden Street quarries, District of Columbia, and the structure of the gneisses in the vicinity of Great Falls, Maryland, under the guidance of G. P. MERRILL and C. N. FENNER. The second excursion was on May 17, 1921, and included visits to the Cambrian and pre-Cambrian rocks near Point of Rocks, and the Triassic sandstones and diabase at Dickerson, Maryland.

The following persons have become members of the Academy since the last report in the Journal (November 4, 1921, p. 443). Except where otherwise noted, the address is Washington, D. C.

Dr. ELMER DARWIN BALL, Dept. of Agriculture; Prof. ALAN MARA BATEMAN, Dept. of Geology, Yale University; Dr. A. F. BEAL, Bureau of Standards; Dr. A. W. BOSWELL; C. E. CHAMBLISS, Bureau of Plant Industry; Dr. GEORGE WHITLEY COGGESHALL, Institute of Industrial Research; J. S. CONWAY, Bureau of Lighthouses; Dr. HOWARD AUSTIN EDSON, Bureau of Plant Industry; Dr. MAURICE CROWTHER HALL, Bureau of Animal Industry; Dr. LEONARD LEE HARTER, Bureau of Plant Industry; Dr. CLYDE EVERT LEIGHTY, Bureau of Plant Industry; S. K. LOTHROP, Peabody Museum, Cambridge, Mass.; RUSSELL A. OAKLEY, Bureau of Plant Industry; R. P. PARROTT, General Electric Company; E. L. PEFFER, Bureau of Standards; Dr. A. G. PIETERS, Bureau of Plant Industry; Prof. CHARLES V. PIPER, Bureau of Plant Industry; R. L. SANFORD, Bureau of Standards; Prof. BENJAMIN SCHWARTZ, Univ. of the Philippines, Los Banos, P. I.; C. M. SMITH, Bureau of Chemistry; Dr. W. T. THOM, Jr., Geological Survey;

G. W. VINAL, Bureau of Standards; Dr. W. P. WOODRING, Geological Survey.

A. E. FATH has taken furlough from the Geological Survey to do private geologic work in foreign countries.

Prof. W. H. HOLMES and Dr. ALES HRDLICKA have been elected Honorary Associates of the Sociedad Cubana de Historia Natural "Felipe Poey" of Habana, Cuba.

CHARLES M. HOY, who for the past three years has been collecting natural history specimens in Australia and Tasmania for Dr. W. L. ABBOTT, has returned to Washington. Mr. HOY secured a very fine collection of both birds and mammals, a large number of them being new to the collection.

Drs. WALTER HOUGH and ALES HRDLICKA have been appointed delegates from the Institution to the International Congress of Americanists, to be held in Rio de Janeiro, the latter part of August. They will also represent the Institution at the International Congress on America's History, which meets at the same place on September 7.

NEIL M. JUDD, curator of American Archeology, who is conducting archeological excavations at Pueblo Bonito, New Mexico, for the National Geographic Society, arrived in the field May 3 and assembled his men and equipment. The work of excavation began May 15, and Mr. Judd holds great expectations of valuable results from this season's work.

Dr. DORSEY A. LYON, chief metallurgist of the Bureau of Mines, has received the degree of Doctor of Science from the University of Utah in recognition of his contributions to metallurgical research.

G. R. MANSFIELD has been appointed chief of the section of non-metalliferous deposits in the Geologic Branch of the U. S. Geological Survey.

Dr. CHARLES L. PARSONS sailed from New York on June 13 to attend the meeting of the International Union of Pure and Applied Chemistry at Lyons, France, June 27–July 7. Dr. PARSONS represents the United States as vice-president of the Union. Other delegates were EDWARD BARTOW, E. S. CHAPIN, R. B. MOORE of the Bureau of Mines, E. W. WASHBURN of the National Research Council, and H. S. WASHINGTON of the Geophysical Laboratory.

Word just received from the Canal Zone announces the safe arrival there of DR. F. W. PENNELL, Curator of Botany in the Academy of Natural Sciences, Philadelphia, who, accompanied by MRS. PENNELL and by MR. E. P. KILLIP of the National Museum, is en route to Colombia, where about six months will be spent in botanical exploration in the central and western cordillera. From headquarters at Cali work will extend northward to Medellin and southward toward the Ecuadorean border. The exploration should be successful not only in assembling a large amount of topotypic material but also as affording an opportunity of collecting in new and interesting territory, western Colombia being as a whole little known botanically. In this exploration the New York Botanical Garden and the Gray Herbarium are coöperating with the two institutions mentioned.

WILLIAM SCHAUS was elected, on April 5, an honorary member of the Sociedade Entomologica do Brazil in recognition of his extensive work on the butterflies and moths of Brazil.

ATHERTON SEIDELL of the Hygienic Laboratory, U. S. Public Health Service, is spending several months in Europe with the special purpose of comparing American and European methods and progress in the study of vitamines.

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GEOPHYSICS.—*A plea for geophysical and geochemical observatories.*[1]

T. A. JAGGAR, Hawaiian Volcano Observatory.

A volcanic system is known to the volcanologist as a place, not merely of kinds of processes, but of measurable events. In the course of events processes change. Nowhere is this so true as in a physico-chemical system dependent on pressure, temperature and saturation. The volcano edifice is a furnace changing these things in accordance with fixed laws of accumulation, of movement of the crust of the Earth, and of reaction with the watery and atmospheric envelopes that encase the crust. The relation of the volcano and its processes to these changing features of the globe through the seasons and the years, incessantly measured, is the most fundamental control for all the processes. Therefore the sending of geological expeditions concerned only with a process here, and a process there, will no more solve the volcano mystery than the sending of an expedition to Mauritius to observe an eclipse will resolve the orbits of the solar system. Let the astronomers say which is the more important, an expedition or an observatory. The expedition may furnish vitally important methods and data. Only the coöperation of fixed stations can collect these into a constructive science.

The comparison of geology with astronomy may be profitable to geology from another angle; namely, the application to the science of special invention and expensive apparatus. Astronomy and geology both deal with enormous bulks, gradual migrations, physical processes, chemical reactions, hidden masses revealable only by the aid of instruments of precision. From the time of Lyell geology has been increasingly dependent on the study of the living Earth to interpret the past. The life of the Earth's interior and of its outer shells, through the time of the present generations of men, is just beginning to be studied. With due allowance for the contributions of terrestrial gravity, geodesy, magnetism, and seismology, all of recent date,

[1] Received November 21, 1921.

produced rather by engineers than by geologists, the science of the Earth has yielded no Herschel, Huggins, or Hale, intent on improving the tools of the workman. Sorby's work on the petrographic microscope was good, but that was mineralogy, not measurement of the Earth. The hammer and compass still suffice for the geologist, and he borrows an aneroid or a transit from the engineer. No elaborate fluviometer costing hundreds of thousands of dollars stands on the banks of the Mississippi or the Ganges, comparable to the improved speculum of the star gazer. No mighty oceanometer has been invented for penetrating the deeps of the sea—unless it is the submarine, not yet available for the geologist. And no great Alpine observatory exists, with a staff of forty trained physicists and computers, and instruments which look inward at the core of the Himalaya and interpret every movement of uplift and erosion in terms of physical process and progress. Is this because the living Earth is less important to mankind than the number of units in a star-cluster or the diameter of a heavenly body? And yet nowhere on Earth, so far as known to the writer, is there a skilled geophysicist and inventor giving his whole life to an observatory devoted to measurement of change in a river system or a mountain range.

The perpetual measurement and record of these changes and their minutiae will not be done "somehow" or "anyway," and the results be stored in the libraries. It will not be done by travellers. It will not be done by teachers of school geography. It is not being done by engineers and governments and geological surveys. Little qualitative dabs are being done here and there but not quantitative records that will show cycles and crises, that may be platted as curves of change, that will create formulas useful in the discovery of the indices or coefficients of process for different places and climates.

The writer, from his experience of a decade of recording on an active volcano, is convinced that all that he learned in seven volcano expeditions to distant lands was as nothing compared with a few years in a fixed experiment station. He never had the slightest suspicion, from the travellers' accounts, of the number of changes which occur in a short time. Processes of which he never dreamed are dominant. Physical statements by reputable persons are proved wholly erroneous. Dimensions, even when estimated by engineers, are exaggerated. Interest never flags. Measurement of change becomes increasingly precise and the charts become increasingly illuminating. New problems open out endlessly and new experiments are suggested.

The old experiments get new meanings and need repetition with more precise method. Every day of observation opens up a new query.

The psychology of casual scientific visitors at Kilauea throws light on the statements which were made and recorded by similar travellers of a half-century ago, citing white heat, lava liquid as water, absence of flames, clouds of steam, floating islands, melting by lava, excessive heights and depths, and loudness of noises. The misstatements are due to failure to observe gases and their effects, and to preconceived notions, inexperience, hasty generalization, and the tendency to exaggeration which is never so dominant as on an active volcano. The will to explain is so much more active than the will to doubt and ascertain, that a bag-full of erroneous notes is carried off in triumph. As a matter of fact, doubting and waiting is necessary in presence of the unsolved and difficult problems of volcanism, the most enigmatical field in geology.

I recently asked the Research Information Service of the National Research Council about funds for fixed experiment stations dealing with eruption, erosion, sedimentation, and deformation as objects of measurement. Numerous inquiries by that Service failed to discover any specific provision for the kinds of research designated. Volcanology and seismology are meagerly supplied with fixed stations recording secular changes. Uplift and tilt in mountains and shorelines, erosion, and sedimentation, are not subjects of even experimental measurement having in view pure geology.

The sedimentation symposium directed by T. W. Vaughan is an admirable compilation revealing recognition of the need for a new method, but nowhere suggesting the observatory method. The phrasing refers to "problems" and the "need for critical studies" and correlation and classification, always with a mapping or a series of specimens in mind. Almost none of the experts has in view permanent secular measurement of rate of change and of kinds of change.

This idea suggests to the geologist an impossibility. He instantly says, "It would take too long." I reply, "Not only are you wrong, but your clocks must be set to Greenwich time and must split seconds to measure some of the accelerations of your sedimentation process. These sediments are filling intramontane basins, burying cattle bones on the plains, and shallowing the Gulf of Mexico." "Who has done any such work?" he asks. I answer, "George Ellery Hale at Mount Wilson." "But surely," says my friend, "you can't expect to do

that in geology, *for the Earth is so much more complicated.*" Whereat I laugh. He has asserted that the Earth is more complicated than the universe. His difficulty is due to confusion of ages of strata with the physical conception of rate of change. The hour, minute, and second are just as important to geology as era, period, and epoch. The first half of the textbooks of geology is misnamed "dynamical," for it contains no measurements of dynamical facts. The measurements needed will be rough at first, but they will gradually grow precise. This has been the history of meteorology and seismology, and geonomy is the same kind of science.

Dr. Daly has said that science is drowning in facts. Geological science is utterly lacking in measured facts of change within human time. Astronomical science is wholly made up of precision measurements of change within human time. Has this discouraged the astronomer? Dr. Hale says the supreme problems are the constitution of matter, the evolution of celestial bodies and the structure of the universe. The supreme problem of the Earth is the application of atomic theory to the evolution of the globe as a celestial body. Eruption, erosion, sedimentation, and deformation are surface manifestations of terrestrial evolution, just as comets, orbital motion, novae, and sunspots manifest celestial evolution.

When an astrophysical problem is to be solved, a certain star or nebula is selected as a type. The same thing may be done for sedimentation. Geographically delimit a certain strategic area and measure the changes there in relation to gravitation, crustal motion, atmosphere, water, and topographic form. Select an area where processes are rapid, and work thence to areas where they are slow. Do the work with trained physical experimenters and engineers. Do it with a view to pure geology, for purposes of discovery, and without economic bias. And finally, do it with the expectation that the institution will live after the individual has withered. The floods of a decade will yield unexpected results, the rates of accumulation will show seasonal and other rhythms undreamed of before, and, best of all, the problems which will open out for experimental treatment will themselves be surprises. If properly financed and manned, such a station will be more quoted than the Challenger expedition, and will take rank with Mount Wilson.

TENDENCIES IN THE GROWTH OF GEOLOGY

It is of interest to review the growth of geology for seeing whither

it tends. Like other sciences it originated in the needs of commerce. Just as botany grew out of "physic gardens" adjunct to medicine, so geology sprouted from the necessity of knowing coal and iron. Explained at first as abortive efforts at creation, the fossil shells and leaf imprints of the coal measures later became the hobby of doctors and curates inspired by William Smith and Lyell. In America vast mappings bred a hardy band of geologists, supplemented by topographers and railway men, exploring a wilderness of plains, deserts, mining districts, and mountains. These workers were partly army engineers, and for Britain such men also explored India and the Himalaya, and the problems of mass and magnetism, river erosion, climatal change and volcanic heat gained increasing prominence, when physically trained minds brought experimental method to bear on what had hitherto been merely descriptive. Next came formal organization under Government for studying rivers, harbors, the weather, sea bottoms for laying cable, the tides, terrestrial gravity and magnetism as affecting the instruments of astronomy, and the necessities of construction against fire, hurricane, flood, and earthquake. Agriculture, navigation, inland transport and mining, urban life, post and telegraph service, public time-keeping—all of these utilities are what have demanded expenditure of the public money to train experts in Earth process, just as coal and iron first produced experts in Earth history.

Earth history is dependent on Earth process, just as life is dependent on food, air, blood and brain. The physician of the one as of the other must have clinical experience. No geologist can doctor a coal mine who has never seen coal in the making. This is a startling assertion, but is it not true? Can any physician, not a quack, doctor blood and brain, restore life to morbid tissues, or even localize a bone, if he has made no experiments in hospital and dissecting room?

The whole of geology is increasingly leaning upon present history, Earth energy, geophysics. But we have seen that the historical science and the physical have independently sprouted from utilitarian needs. They have never been blended to aid each other as pure sciences. The toilers of the copper and iron mines, economic geologists, pick up crumbs that fall from the laboratory tables of the students of terrestrial gravity and magnetism, and vice versa, but neither understands the other's problem. I think it is true that neither geologist nor geodesist is making the slightest effort to find a place in the world today where copper and iron ores are being natu-

rally segregated, and there to study their electrical and gravitative effects. And yet at the Hawaiian volcanoes copper and iron sulfates and iron oxides are visibly concentrating, the magnetic declination values are various in an absurdly aberrant fashion, and the gravity phenomena of the heavy basaltic mountains are known to be extraordinary. All of this may be the key to Mesabi iron and Keweenawan copper, in ancient volcanic lands, but never an expert from those mines has come to Hawaii to find out.

OBSERVATORIES VERSUS EXPEDITIONS

The economic motive is apt to come to the front. Direct service to mankind is the measure of success. If this test is applied in the case of geology *vs.* geophysics, the customary alignment which places geology first (as explaining coal, petroleum and iron) may be defective. The Mississippi river system means more to more people than the succession of strata in the Illinois coal fields. Yet we know the Illinois coal fields, and no man living knows the Mississippi river system. The bogs may be making coal. No man knows the bogs. So we could run through the category of shore-lines, sea-bottoms, mountain streams, glaciers, springs, deserts, sand dunes, deltas, tide flats, volcanoes, and snowy peaks and show that no one knows the processes now going on, now changing and moving these things, in the sense of having measured them in relation to the passage of time. Just as a volcano occasionally reaches a crisis, so it is with a peak, a glacier or a delta; except by hearsay, no one knows these critical points or their controls. The peak may be breaking down, the glacier reaching a pressure limit, and the delta a limit of weight or height. An engineer with a ten million dollar contract dependent on knowing such rate of change would spend ten years, if need be, to measure it.

One of the most striking developments of continuous measurement at the Hawaiian volcanoes is the revelation of rhythmic recurrences. There are tides in the lava with maxima near midnight, a systematic upheaval of the solid crater floor by two or three feet every night. There are weekly, monthly and semi-annual culminations. There are cycles of about 9 years' duration, and there are possible cycles of 65 and 130 years. There may be longer cycles measured in tens of centuries. Rhythmic control appears in the tremors, earthquakes, and tilts with periods ranging from a half-second to a half-year. Anyone who has ever seen a loose monkey-wrench creep along the footboard of a vibrating motor-car is led to wonder whether this tremulous creaking earth-crust is not shaking down its mountains and its sedi-

ments by a similar mechanism. The determination of these periodicities has depended on the founding of an observatory, and only a decade of work has already laid the foundations for much useful discovery. Many phenomena before deemed exceptional are found to be commonplaces (Pelee spine). Others neglected before are found to be fundamentally important (aa lava). Chemical processes which were taken for granted, like oxidation, begin to loom large. Elements difficult to detect because of unperceived combustion and rapid diffusion, like hydrogen and helium, may prove more important in explaining volcanism than any of the obvious things. Chaotic-looking results are achieved by surprisingly gradual processes, even in volcanism, and immense bulks are moved rapidly with astonishingly little disturbance.

A temporary expedition cannot be expected to discover such things. An expedition expert is not expert in knowledge of the habits of the place he is visiting. So-called intensive studies by expeditions cannot reckon with past, present, and future critical events. The time element in physical control entirely breaks down. Agassiz in Galapagos found green slopes; he was amazed that Darwin had reported barrenness. They were there at different seasons. Often the evidence of a local consul or physician is more valuable than the opinion of experts. The solution of the coral reef problem is a Fiji observatory; the solution of the continental glacier problem is a Greenland observatory; the solution of the ore-deposit problem is a series of volcano and hot-spring observatories; and the solution of the erosion problem is a Mississippi observatory. Piecemeal notes patched together from library reading never yet made a discovery in natural history and never will. Human observation is such that often it must dwell with an obvious fact which it never sees for many years, until suddenly there comes an awakening. This is a commonplace of scientific progress, as biography shows. The specimen and the descriptive note are makeshifts, intolerable in the experimental sciences such as physiology, astrophysics, or meteorology; how large a part does a mummy, a meteorite, or a hailstone play in those sciences? So it is with geonomy, the science of Earth law. Men dwell on the Earth and live by its forces. No statement can be too strong in enforcing the importance of Earth processes for man.

In America the names of Dutton, Dana, Gilbert, Russell, Becker, Powell, McGee, Shaler, and Clarence King recall personalities of men who saw erosion, gravity, desiccation, accumulation, uplift,

unweighting of the Earth-crust, lifting of loads, and all such motions as more important, for their generalizations concerning past history, than anything contained in the dead rocks. They also studied these processes in action within the limits of their broad reconnaissance of a mighty continent. That reconnaissance expected a measurement of these movements by the next generation. The literature of geology is overburdened with expressions such as "possibly," "probably," "it may be assumed," "perhaps," and "according to current conceptions," all of which tend to hold it back from becoming a quantitative science.

The expedition method of intensive study of field problems is never free from the reconnaissance element, because of the unexpected phenomena which demand the manufacture of special instruments. Again and again in the writer's experience he has found himself in strange lands without the proper tools. However carefully prepared the equipment, pyrometers, gas-collecting devices, thermometers, sounding apparatus, transits, alidades, cameras, cableways, dredges, signals or what not, the explorer with limited time at his disposal finds that "here is the supreme opportunity" for so and so, and he has neither the man nor the equipment to test it. Perhaps it is merely one little piece of some peculiar metal or glass that he needs, perhaps it is a whole man, learned in atmospheric electricity, or a gun for throwing a rope, or a glass-blowing equipment and someone who can do the work. No matter how large and complete a shop and laboratory on the ship, there is needed a casting, a lens, or an implement made of fused quartz, and the vessel cannot produce it. Every recent expedition reports such happenings, owing to the great complexity and variety of requirements of modern science. Here is where the fixed observatory, if properly equipped and strategically placed, with machine-shops available and time to get men and apparatus as needed, and a whole life-time of deliberate work before the staff, can do what the expedition is not fitted for. Coöperative experts may be called in as occasion demands. The great endowed research establishments of the world attest the advantage of fixed stations, and the time has come for applying the method to geonomical processes.

A RIVER OBSERVATORY

Imagine a Fluviometric Observatory for the permanent increase and diffusion of knowledge about everything pertaining to the geophysics of the Mississippi river from the Yellowstone to the Alleghanies and from New Orleans to Minnesota. Its staff of physicists,

chemists, engineers, and assistants would be charged with the task of experimenting upon and measuring everything that can be learned concerning the changes in progress in the Mississippi, its basin, its sources, its waters and its sediment. Ultimately this institution would learn the natural history (literally) of that great organism, and the meaning of its presence and its probable future. This would yield new knowledge of other rivers, the Nile, the Congo, the Amazon, and of the philosophy of river basins in the economy of the continents. On no account would the observatory start with any preconcepts of physical geography. Its work would be purely quantitative and wholly devoted to water chemistry and the physics of gravitation and hydraulics acting on a complex surface to drain that surface and lower it by erosion acting under isostatic compensation. Isostasy, tilt, rainfall, temperature, wind, earth pressures, analyses, springs, rock decomposition and creep, silting, laking, floods, erosion pattern, earthquakes, uplift at fixed bench marks, biological controls, and delta sedimentation would be among the chapters in the record book. Mappings and repeated levellings would be among the station's achievements. New constants, new units and a new terminology would develop. No existing doctrine of orogeny, erosion, or sedimentation would be taken on faith—all would be tested in the crucible of relentless measurement through seconds, days, years, decades, and centuries. I would like to see such an institution liberally endowed, and as rigorous as the Bureau of Standards. Is there not a wealthy Mark Twain somewhere who loves the great "Father of Waters" enough to catch the vision of this institution, and what it would do for the world of men and the world of science?

A MOUNTAIN OBSERVATORY

It is worthy of comment that very few naturalists possess names immediately associated in the public mind with the places they have illumined by dwelling there. Heim for the Alps and John Muir for the Sierra are types by way of illustration. There are those who have made many trips to the Rocky Mountains and have brought home specimens. But have they listened to the Rocky Mountains breathing in winter and summer, have they measured the change in cliffs and creeks and sage-brush flats, do they know the tremblings and the tiltings measurable in rock chambers in the face of a towering peak, have they for decades long surveyed lines from peak to plain, checked with levels? Have they studied the swayings of a mountain lake, the rise and fall of the brooks in springtime, the boilings of the geyser

basins, and timed the avalanches in the uppermost cirques? One can imagine a philosophical old prospector resident there, who knows more of the living forces that build the Rocky Mountains than any visitor. Not only must he who would be Master of the Mountain dwell there, like Seraphita amid her fjords, but he must work there and make lifelong measurements of change, until his faith has truly made the mountain move.

Anyone who has spent summers with pack-train in a place like the Yellowstone comes to know the land to be leaping. All night in camp 9000 feet above sea-level one hears the rocks from the precipice tinkling, sliding, crashing. A glacier booms through a deep crevasse. The milky stream carries off powdered rock by tons. A geyser terrace is hot, expanded; a neighboring summit is snow-clad, contracted. A herd of elk bounds up the slope with a clatter of rocks disturbed; every stone has been impelled nearer to sea-level. We hear much talk of water erosion; this is a land where tumbling and sliding do just as much as water. The mountains are falling all the time and by millions of tons. Something underground is shoving them up. Occasionally there is the whirlwind crash of a whole mountain-side, like the disaster at the mining village of Frank, Alberta. How many scores of similar slides occur in lonely places where no one even hears the noise? And how often? How much is the ground tilting? The genius who finances and mans the first mountain observatory will found a new science. Similarly we may imagine shore-line, glacier, desert, and sea-bottom observatories, ever inventing new instruments and revealing an unknown world.

Physical chemistry has worked wonders by synthesis in the laboratory, exploring rigorously a wide range of saturations, temperatures and pressures. There is needed direct comparison of these results with the complex analyses and syntheses which nature is always achieving. The comparison with mineral specimens studied in the polarizing microscope has been useful, but it is not enough. The astrophysicist never contents himself with a meteorite. Invention of field methods in geophysics is not keeping pace with laboratory skill. In contrast to the ultimates of modern physical research, the processes of the middle ground such as the motion of Tyndall's glaciers and the submarine subsidence postulated by Darwin are worthy of permanent stations, large staffs of specialists, big instruments, and endless refinement of measurement. The workers should live and die in their chosen field, they should create their own social group,

with students to act as assistants and computers, and welcome visiting travellers as co-workers.

Geological experiment stations on the mountains of Antarctica, the volcanoes of Chile, the sands of Sahara, the tide flats of Fundy, the foothills of Himalaya, the forks of the Amazon, eternally measuring creep, tilt, temperature and flood, will become famous not only as harnessing the globe with a web of pure reasoning, but will be fertile ground for sowing the seeds of peace and international coöperation. Science has been well described by Soddy as man's most eclectic religion, and no nation can object to an invasion by scientific missionaries.

The basis of physical geology resides in hydrogen and the evolution of the elements just as in the case of astronomy. But astronomy is basing all its newer work on astrophysics and astrochemistry. It is frankly pure and does not worry about getting itself applied. Earth science needs a new stimulus in the same direction. The observatory method furnishes a worthy and adventurous outlet for the pent-up energies of inventive young men trained in geophysics and geochemistry.

PALEONTOLOGY.—*Two new aphids from Baltic amber.*[1] A. C. BAKER, Bureau of Entomology.

In several blocks of Baltic amber recently purchased by the writer, there are preserved two interesting species of aphids, and a study of these specimens throws considerable light on the family as a whole. In the writer's generic classification[2] the genus *Mindarus* Koch was used as the basis of the subfamily Mindarinae, a group supposedly dominant in earlier times and quite distinct from the Eriosomatinae in which it had formerly been placed. Only one living form is known, *Mindarus abietinus* Koch, a cosmopolitan aphid living on conifers.

The blocks obtained show two alate specimens of a *Mindarus* very similar indeed to *abietinus* and a young nymph which we believe represents one of the earlier instars of the same thing. The remarkable similarity between this amber form and our common species can be seen by glancing at the figures in which the parts have been drawn to approximately the same size.

That the genus *Mindarus* was formerly well represented seems to be fairly assured. *Aphis transparens* Germ. & Ber.,[3] also from amber,

[1] Received July 26, 1922.

[2] Bull. 826, U. S. Dept. Agr. 1920.

[3] Org. Reste 2[1]: *pl. 2.* 1856.

undoubtedly belongs here. In fact it may even be the same species as that herein described. Unfortunately the description is very inadequate and it is only from the drawing of the wings that the species can with certainty be placed in the genus. *Lachnus dryoides* described by the same authors at the same time seems so similar to our immature form that there may be good reason to conclude that it represents young nymphs of *transparens*. This is also born out by the reports of other workers. Out of fourteen alate specimens found by Menge[4] in amber he referred thirteen to *transparens*, and along with these he found abundant a form which he referred to *dryoides*. In the same way Mochulskii[5] lists *dryoides* as the most abundant species represented in his material. Scudder[6] has erected many new genera from Florissant, basing them on the angle of the wing veins, a procedure which would seem dangerous in view of the fact that living forms show variation in this regard. He believed that the American forms are mostly quite distinct from the European ones. "American fossil plant lice," he says, "appear as a rule to differ from the winged forms so far described from the European Tertiaries with the single exception of the species figured by Berendt from amber under the name *Aphis transparens*..... The species is indeed an Anconatus."

Through the kindness of Nathan Banks I have been able to examine the Scudder material in the Museum of Comparative Zoology at Harvard. *Anconatus dorsuosus* Buckton, type of the genus, is represented by Numbers 3228 and 11175. Number 4827, from which Scudder's figure was made, is not present. The specimens on the other two blocks are not adequate to determine definitely the placing of the species. Neither can this be done from the drawing but Scudder's description, which seems not to agree with his figure, indicates that the species is probably a *Mindarus*. The ground is much more secure in the consideration of *Schizoneuroides scudderi* Buckton. From the very typical figure given by Scudder one would believe this species to be a *Mindarus* and an examination of the specimen shows this to be the case. Scudder's figure of *Pterostigma recurvum* Buckton suggests that this species also is a *Mindarus*. The drawing, however, does not seem to agree with the specimen. While the cubitus and anal are about as indicated, the media seems to arise much nearer the

[4] Progr. Petrischule. 1856.
[5] Etudes Ent. 5: 29. 1856.
[6] Tert. Ins. 1890.

radial sector. The general character, however, seems to be that of *Mindarus*.

It would be impossible to place definitely with their allies many of the species described by Scudder. One thing, however, seems certain. None fall in the subfamily Eriosomatinae (Schizoneurinae) in which he placed them. While details of structure cannot be seen, this fact is evident from the general nature of the specimens.

With the exception of those forms falling in the Mindarinae, all of Scudder's specimens, with one exception, are different from forms in recent genera. This species is *Oryctaphis lesueurii*. I am unable to make this form agree with the description and figure unless what shows as the stigma and radial sector are something quite different. The stigma appears to be truncate and the radial sector short and heavy like certain recent forms in the Lachnina. If this is actually the case, it indicates a remarkable difference from the other Florissant forms, all of which possess an extended stigma and a long radial sector arising far back on it. *O. recondita*, the second species of this genus, is quite different. It is very large and is not improbably a *Mindarus*. Scudder's figure hardly gives an accurate representation of it. The radial sector arises near the base of the stigma. The media can be traced almost to its base, and a branch is indicated very near its tip, much nearer than indicated in Scudder's figure. Scudder believed that this vein was twice branched but I believe the branch visible in the specimen to be the only one and that the insect might with good reason be grouped with *Mindarus*.

Many of the fossil aphids in the Scudder collection are not well preserved and it is perhaps as well to let them rest in the genera he described for them. Certain general characters are, however, worthy of mention. The most striking is the extension of the stigma and the insertion of the long radial sector. In many specimens the antennae are very long, suggesting some of the slender antennae in the Callipterina. Cornicles appear not to be present, and there seems little doubt that if the aphids possessed these heavily chitinized structures in any prominence traces of them would be preserved with the less delicate ones. Prominent cornicles are present in some of the species in amber, but these species have quite a recent aspect. We are forced to conclude that the cornicles were not prominently developed when the Florissant deposits were laid down. In only one specimen can I find traces of what may have been cornicles. This is a form which Scudder described as *Aphidopsis* sp. (No. 1044). In his description

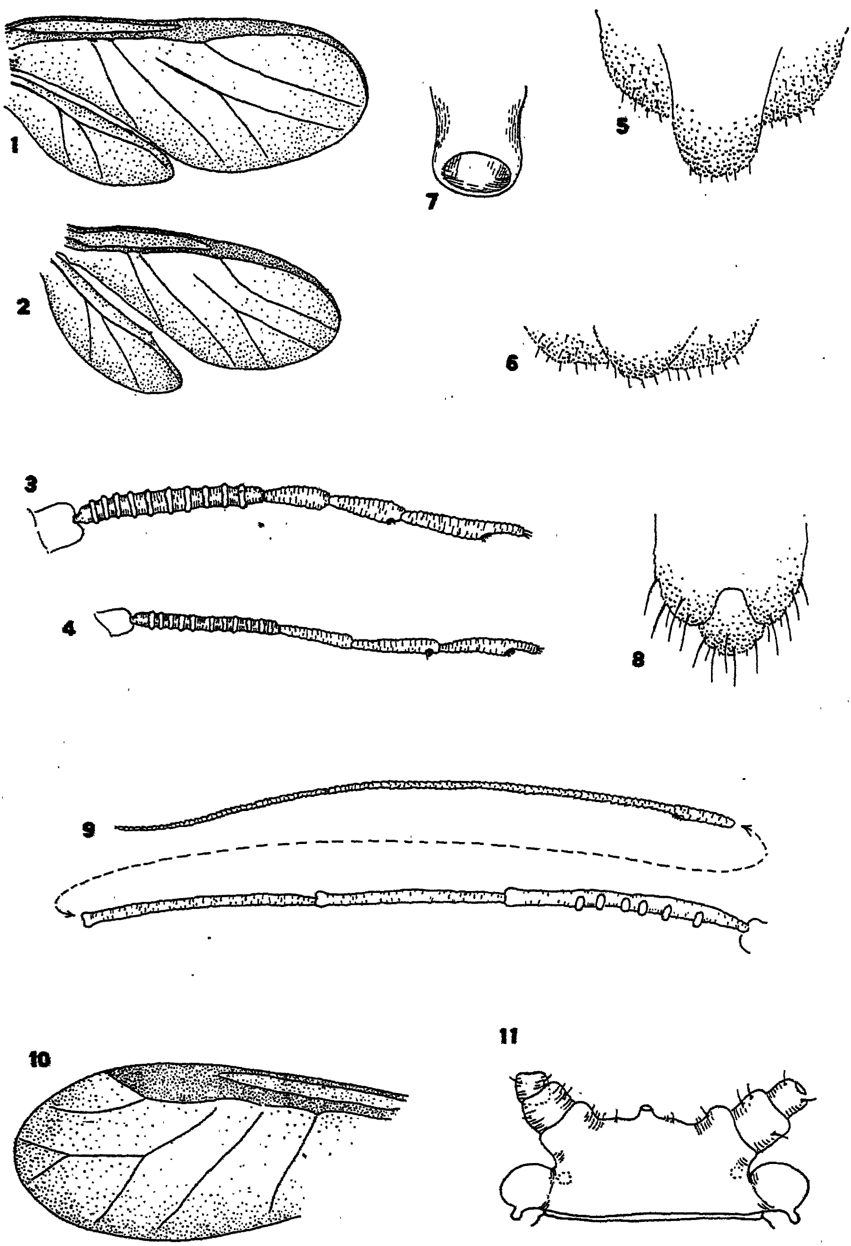

Fig. 1.—1, *Mindarus magnus*, wings; 2, *M. abietinus*, wings; 3, *M. magnus*, antenna; 4, *M. abietinus*, antenna; 5, *M. abietinus*, cauda and anal plate; 6, *M. magnus*, cauda and anal plate; 7, *Calaphis scudderi*, cornicle; 8, *C. scudderi*, cauda and anal plate; 9, *C. scudderi*, antenna; 10. *C. scudderi*, fore wing; 11, *C. scudderi*, head.

he mentioned these structures and described the insect as immature. It is, however, an alate specimen which has lost the wings, or possibly an intermediate, for the structure of the thorax is well preserved and the ocelli are visible. The cornicles, if they are cornicles, are broad at the base, short and somewhat tapering. The cauda seems to be knobbed and the anal plate bilobed. The entire insect suggests the genus *Euceraphis*.

A detailed reference to the other specimens in the collection could add little to the knowledge already available, but I believe that the remarks here given, together with the detailed description of the amber species, are sufficient to support the view that *Mindarus* is a genus formerly dominant but now represented by the solitary, cosmopolitan, conifer-feeding species *abietinus*.

The descriptions of the amber species given herein are the first in which any attempt has been made to give the more minute details of structure as is done in the description of living forms. This has been possible by use of the same high magnification adopted in studying recent aphids and the employment of powerful illumination. Even with the best light available, however, certain desirable characters remain obscured.

Mindarus magnus Baker, n. sp.

Alate viviparous female.—Head, thorax, and appendages appearing as dark brown. Abdomen yellowish, possibly greenish in life, with a large dark central dorsal marking irregular in outline. Wings transparent, the veins and stigma brown.

Length from vertex to tip of cauda 2 mm., width of head across the eyes 0.48 mm. Fore wing (Fig. 1) 2.88 mm. × 1.2 mm. at its greatest diameter. Hind wing 1.28 × 0.56 mm. Antenna (fig. 3) extending about to the wind insertions, segment III 0.24 mm. with 9 or 10 transverse sensoria, IV 0.08 mm., V 0.096 mm., VI (0.112 + 0.048 mm.), these segments distinctly imbricated and bearing the usual fringed sensoria. The measurements given for the antennal segments cannot be considered absolutely exact in view of the fact that they are not perfectly horizontal in the amber. In the second specimen, segment III of one antenna is 0.304 mm. long and segment IV appears to have 2 or 3 sensoria. Cauda and anal plate not distinctly visible but apparently as in Fig. 6, cauda possibly more extended in life. Cornicles obscured. Beak long, extending to about the middle of the abdomen.

Nymph.—What is possibly the 2nd instar of this species is herewith described.

Length from vertex to tip of cauda 0.896 mm. Length from vertex to tip of beak 1.36 mm. Antennal segments with the following measurements: I 0.032 mm., II 0.048 mm., III 0.032 mm., IV 0.032 mm., V 0.048 mm., IV (0.048 + 0.048 mm.). Form elongate, rather slender, segmentation distinct, color appearing brownish.

Mindarus magnus differs from *M. abietinus* in being much larger, in having a longer beak and in having somewhat stouter and relatively shorter antennae.

Described from three specimens in as many blocks, two alate specimens of which the type has the wings spread and one young nymph. The type and paratypes are temporarily retained in the author's collection.

Calaphis scudderi Baker, n. sp.

Alate viviparous female.—Head, thorax, and appendages appearing dark brown. Wings transparent with rather heavy veins. Abdomen brownish with dark markings above.

Length from vertex to tip of cauda 1.28 mm. to tip of wings 1.92 mm. Head (fig. 11) with the eyes very prominent and the antennal insertions distinctly transverse, median ocellus outstanding. Antenna (fig. 9) as follows: III 0.352 mm. with a row of sensoria which stand out distinctly, IV 0.256 mm., V 0.32 mm., VI (0.08 + 0.864 mm.). Segments distinctly imbricated, the distal one with the base not prominently marked off from the unguis, in this respect resembling *Monaphis antennata* (Koch). Cornicles (fig. 7) faintly visible but apparently short, somewhat tapering, with a slight constriction, and a large opening. Wings not unusual, the fore wing (fig. 10) showing a truncate stigma with a short distally set radial sector which is little curved

Cauda and anal plate (fig. 8) not clearly visible, but the anal plate somewhat bilobed and the cauda from the visible portion in all probability knobbed.

Described from one specimen with the wings folded over the back. Type temporarily retained in the author's collection.

I have placed this species in the genus *Calaphis* because it seems nearer this than to any described and I am loath to erect a new one for its reception. It represents a type of insect not present in the Florissant material but which is the usual type of living forms. This is especially evident in the wing, in the shape of the stigma and the radial sector. It indicates that while the more primitive forms represented by *Mindarus* are present in the Florissant beds and abundant in amber, the more recent type, dominant today, appears only in the amber.

GEOLOGY.—*The Lower Paleozoic section of southeastern Pennsylvania.*[1]

GEORGE W. STOSE and ANNA I. JONAS, Geological Survey.

The facts here presented are the results of comprehensive geologic studies in connection with detailed surveys in southeastern Pennsylvania by the writers and Eleanora Bliss Knopf for the Federal Geological Survey and the Pennsylvania State Geological Survey. A brief preliminary statement of the Paleozoic section that has been worked out and the formation names that have been applied are given in this paper.

Twelve miles east of Lancaster, Pa., the Cambrian quartzites of Welsh Mountain plunge southwestward beneath the limestones of the Lancaster Valley and rise again a few miles west of Lancaster in the Hellam-Chickies Hills.

[1] Published with the permission of the Director of the U. S. Geological Survey and the State Geologist of Pennsylvania. Received August 5, 1922.

The divisions recognized in the quartzites and limestones of this area and described below, are as follows:

GENERALIZED COLUMNAR TABLE

Age	Name	Thickness (ft.)	Character of Rocks
Ordovician	Conestoga limestone (probably older than, or in part equivalent to, Cocalico shale)	500±	Dark slaty limestone, coarse limestone and marble conglomerate, thin-bedded granular blue limestone, and thin graphitic slate. Contains brachiopods and crinoid plates and stems of probably Chazy age. Overlaps southeastward on all formations from the Ledger dolomite to the Harpers schist.
	Cocalico shale	1000±	Dark gray shale containing graptolites of Normanskill type and thin crinoidal limestone at base; gray, green, and purple slates and green impure sandstone above.
	Beekmantown limestone	2000±	Light blue limestone and some light gray magnesian limestone and dolomite, containing a little chert. Carries Beekmantown fossils.
Upper Cambrian	Conococheague limestone	900±	Massive blue limestone containing Cryptozoon reefs, thin-bedded wavy laminated limestones, sandstones and sandy conglomerates, and dolomite.
Middle Cambrian	Elbrook dolomite	500±	Cream-colored to white, fine-grained impure marble, mostly thinly laminated; weathers to shaly yellow tripoli and yellow earthy soil.
	Unconformity		
Lower Cambrian	Equivalent to Tomstown dolomite: Ledger dolomite	1000±	Granular, gray to white dolomite, mostly thick-bedded, some beds of which are siliceous and weather to rust-stained granular cherty layers.
	Kinzers formation	150	Siliceous banded dark blue limestone, impure dolomite weathering to dense buff tripoli, spotted white marble with wavy impure partings, and shale which contains an *Olenellus* fauna.
	Vintage dolomite	500–650	Massive, glistening, coarse-grained, dark gray dolomite, weathering whitish with scattered crystalline blebs, and dark blue dolomite with argillaceous partings, weathering knotty or lenticular.

			Hellam-Chickies Hills	Welsh Mtn.	
Lower Cambrian	Arenaceous series	Antietam quartzite	200±	150±	Vitreous and granular impure quartzite, the upper part of which contains *Obolella* and trilobite fragments.
		Harpers phyllite	1000±	1500±	Greenish gray phyllite or biotite schist.
		Chickies quartzite	1000	550	Massive-bedded, *Scolithus*-bearing, light-colored vitreous quartzite, grainy quartzite with clear quartz grains, and some white clay beds in upper part.
		Hellam conglomerate member	(600)	(150)	Quartz conglomerate, grainy quartzite with rounded clear and blue quartz grains, and slate chlorite schist at base in Hellam Hills.
		Unconformity			
	Pre-Cambrian				Greenstone and aporhyolite in Hellam Hills; gneiss and granitic rocks in Welsh Mountain and Barren Hills.

Most of the Lower Cambrian arenaceous series is well exposed in the gorge of the Susquehanna River through the Hellam-Chickies Hills. The quartzite at Chickies Rock has been called Chickies quartzite since 1878, when the name was first used by Lesley and Frazer; they also used Hellam quartzite for the same rocks in Hellam Hills. Lesley and Frazer applied the name Chickies (Chickis) to the quartzite and associated "quartz slate" but not to the overlying phyllite, and later Walcott followed the same usage, applying the name Chickies to the quartzite. Conglomerate at the base of the arenaceous series was not mentioned by these early writers and apparently was not seen by them, as it is not exposed at Chickies Rock. It is brought to the surface three miles to the west in the midst of the Hellam Hills, where the anticline rises higher, and is there included in what was later called by Lesley Chickies quartzite. These basal conglomeratic beds, to which the name Hellam conglomerate member is here applied, correspond in general with the Weverton and Loudoun formations of South Mountain. The Hellam conglomerate member lies on epidotic amphibolite schist or greenstone and aporhyolite, which are altered volcanic rocks related to the pre-Cambrian metabasalt or Catoctin schist and aporhyolite of South Mountain. The basal beds of the conglomerate here are chlorite schist which contains glassy quartz grains and flat fragments of chloritic and rhyolitic schists,

apparently pebbles derived from the disintegration of the underlying greenstone and aporhyolite. The higher beds are dark slate and pebbly vitreous quartzite with interbedded coarse conglomerate which is made up of crowded round white quartz pebbles, 2 to 4 inches in diameter, in a sericitic siliceous matrix. The thickness of the Hellam conglomerate is estimated to be 600 feet.

The Chickies quartzite as exposed in Chickies Rock is a heavy-bedded light-colored vitreous quartzite and grainy quartzite with slate interbedded near the top, 400 feet thick. The quartzite carries *Scolithus* tubes throughout. It is similar to the Montalto quartzite member of the Harpers schist of South Mountain but as it lies at the base of the Harpers and not in its midst, it is probably not the exact equivalent of the Montalto. The Chickies quartzite, including the Hellam conglomerate member, is about 1000 feet thick.

The Harpers formation of the Hellam-Chickies Hills is a greenish gray phyllite with some biotite.[2] The bedding of the phyllite cannot be determined in most places, but the interbedded quartzite layers show several close folds. Although the thickness cannot be accurately determined it is estimated to be 1000 feet. The phyllite is overlain by light gray, somewhat calcareous, vitreous and granular impure quartzites, about 200 feet thick, some of the upper beds of which weather to a laminated, porous, highly ferruginous rock. These upper beds have the characteristics of certain fossiliferous beds of the Antietam sandstone of South Mountain, and their bedding surfaces show numerous rusty molds of *Obelella* and trilobite fragments. This quartzite is therefore equivalent to the Antietam sandstone (quartzite) of South Mountain.

The senior author has recognized in Welsh Mountain and vicinity the same divisions of the Lower Cambrian arenaceous series as are found in the Hellam-Chickies Hills. The Hellam conglomerate member in Welsh Mountain is made up of a grainy to finely conglomeratic quartzite and coarse quartzose conglomerate at the base, some of the pebbles of which are of clear blue quartz. The chloritic schist which occurs at the base of the section in the Hellam anticline is here absent because the pre-Cambrian rocks of the Welsh Mountain region from which the arenaceous Cambrian rocks were derived is

[2] The rock of the Harpers formation in the Hellam-Chickies and Welsh Mountain anticlines is referred to here as a phyllite to distinguish it from the more metamorphosed rock on the flanks of Mine Ridge, which is a schist. The senior author would prefer to use the term Harpers schist in both areas, which name he has used in previous publications on the South Mountain.

composed of an igneous complex of plutonic rocks and old sediments among which there are no greenstone schists. The pre-Cambrian, however contains conspicuous veins of glassy blue quartz, pebbles of which are inclosed in the basal Cambrian sediments. The conglomerate is well exposed near the sand mines northwest of Honeybrook, where it is only 150 feet thick.

In Welsh Mountain the lower part of the quartzite above the conglomerate is vitreous and the upper part is granular, both carrying *Scolithus* tubes. The granular quartzite is generally disintegrated at the surface and is quarried for sand. It passes upward into a fine-grained, white, siliceous, laminated clay, which is also mined. Four hundred feet of the formation has been measured in quarries and other good exposures. The Harpers phyllite, estimated to be about 1,500 feet thick, is composed of gray sandy phyllite. At the top the phyllite is interbedded with light gray, granular quartzite which weathers to a porous rusty rock containing molds of *Obolella* and trilobite fragments. About 150 feet of the upper quartzose beds are probably equivalent to the Antietam sandstone of South Mountain.

The arenaceous series of the Hellam-Chickies and the Welsh Mountain anticlines is overlain by the limestones of Lancaster Valley. The Vintage dolomite, the oldest of these limestones, is in part a gray, heavy-bedded dolomite, which weathers to a whitish chalky surface, and in part a knotty, dark blue dolomite with argillaceous partings. Some of the beds are sparkling, gray to blue mottled, with siliceous and calcareous blebs that stand in relief on the weathered surfaces. At the base is a whitish, schistose, thin-bedded impure dolomite containing muscovite flakes. This formation closely resembles the Tomstown dolomite on the northwest flanks of South Mountain. It, however, is known to represent only a part of the Tomstown dolomite and is therefore named Vintage dolomite from the small village 15 miles east of Lancaster, where most of it the section excellently exposed in a cut of the Pennsylvania Railroad.

The Kinzers formation which overlies the Vintage is best exposed in the Pennsylvania Railroad cut at Kinzers just east of Vintage. At the base there are a few thin beds of impure dolomite that weather to an earthy tripoli, containing at many places remains of *Salterella*, brachiopods, and trilobites. These beds are followed by a variable thickness of blue hackly shale as much as 50 feet thick in places. Northwest of Lancaster this shale carries abundant trilobites chiefly *Olenellus*, described by Walcott and extensively collected by Professor

Roddy of Millersville, Pa. Above the shale is a variable series of dark banded argillaceous dolomite that weathers to a tough, buff, ribbed, argillaceous rock, sparingly fossiliferous. Some beds are an intimate mixture of nodular white granular dolomite marble and dark impure dolomite that weathers to a knotty pseudo-conglomerate of white marble. South of Welsh Mountain the Kinzers formation is much thinner, in places not more than 25 feet thick, and the shale horizon there is not a prominent feature of the formation. Although no one section clearly exposes all the different beds of the formation, the section at the Kinzers cut is so nearly complete that it is here given in detail.

PARTIAL SECTION OF KINZERS FORMATION IN RAILROAD CUT, KINZERS, PA.

	Feet
Dark blue limestone with wavy impure partings	10
Thick-bedded light gray dolomite	12
Dark-blue limestone with wavy impure partings	6
White spotted marble with wavy buff dolomite partings	8
Blue limestone banded with slightly wavy siliceous layers	10
Highly siliceous banded dark limestone, weathering to skeleton of buff siliceous network	8
Impure thick-bedded dolomite, weathering to dense buff tripoli	3
White spotted marble with even buff dolomite banding	8
Wavy banded blue limestone, numerous argillaceous partings	10
Crumbly, fissile, dark shale, weathering spheroidal	50±
Impure dolomite, weathering to buff tripoli and containing few trilobite fragments and *Salterella*	7
Massive light blue dolomite (Vintage)	—
	132±

The Ledger dolomite, which overlies the Kinzers formation, is a granular gray to white dolomite, generally thick-bedded with few bedding planes. Because the bedding cannot be determined in many of its exposures and because outcrops are few owing to the readiness with which the dolomite weathers to a granular red clay soil, its thickness cannot be exactly determined. It is apparently about 1,000 feet thick. Although fossils have not been found in the Ledger dolomite, it together with the underlying Kinzers formation and Vintage dolomite are believed to be the equivalent of the Tomstown dolomite of Cumberland County. It is named from Ledger, 3 miles northeast of Kinzers.

The Elbrook dolomite, which overlies the Ledger dolomite north and northeast of Lancaster, is an impure, white to cream-colored, fine-grained dolomite marble which splits to fine plates and leaves on weathering and eventually breaks down to fragments of soft buff

tripoli and earthy yellow soil. It closely resembles the Elbrook limestone of Cumberland County and is correlated with it. The Waynesboro formation, a purplish sandy shale which lies between the Tomstown and Elbrook formations in Cumberland County but which dies out northeastward near the Susquehanna River, is evidently not present in this area. Because of poor exposures, the thickness of the Elbrook formation cannot be determined but it is estimated to be about 500 feet.

The Elbrook is succeeded by a series of limestones comprising thick pure light gray limestones which are apparently largely Cryptozoon reefs, thin-bedded finely laminated wavy limestones of related organic origin, sandy conglomerate beds which weather to pitted porous sandstone, and dark blue impure dolomite. This formation corresponds to the Conococheague limestone of Cumberland County. As many of its beds weather to earthy yellow soil similar to that of the Elbrook dolomite it cannot readily be distinguished from that formation on upland surfaces. It is estimated to be 900 feet thick.

Overlying the Conococheague are well-bedded pure blue limestones and magnesian limestones containing gasteropods. The fossils and the lithologic characters determine the formation to be Beekmantown. The Beekmantown limestone is estimated to be about 2,000 feet thick.

The Beekmantown limestone is overlain by a dark gray shale, gray, green, and purple slates, and soft greenish impure sandstone. The dark shales contain graptolites of Normanskill type and have at their base thin crinoidal limestones which are also fossiliferous. It is probably at least 1,000 feet thick. It is named Cocalico shale from the creek which exposes the shale where its relation to the underlying Beekmantown limestone is well shown.

South of the Hellam-Chickies Hills and Welsh Mountain there is a dark slaty and conglomeratic limestone formation that develops to great thickness south of Lancaster and eventually supplants all other limestones. Eleanora Bliss Knopf and Anna I. Jonas have called it in manuscript the Conestoga limestone. It has been traced and studied by them from Lancaster southward to Quarryville and into Chester Valley, but its relations are not there revealed. It was named Conestoga limestone because of excellent outcrops along Conestoga Creek, south of Lancaster. The Conestoga limestone is made up of thin-bedded dark slaty limestone, coarse conglomerate or breccia of limestone and marble pebbles and fragments, thin-bedded blue crystalline limestone, and thin, dark, graphitic slate. Its total

thickness is not known, but it is probably several hundred feet. The marble conglomerates that occur at or near the base were described by Walcott[3] as intraformational conglomerates in the Lower Cambrian sediments. At the Bellemont quarries, 12 miles southeast of Lancaster, one of the many excellent exposures, the conglomerates occur at about the horizon of the banded dark blue argillaceous limestone and knotty white-marble pseudo-conglomerate beds of the Kinzers formation, and at first were regarded by the writers as an expansion of this formation. Later work in other parts of the region has shown that the Conestoga limestone is an overlapping and much younger formation. In the northeastern outskirts of Lancaster, the coarse basal limestone conglomerate clearly fills depressions in the upper surface of the Ledger dolomite. North of Vintage, it overlaps on the Kinzers formation. At the Bellemont quarries it lies on the Vintage dolomite. Five miles south of Vintage it overlaps on the Harpers schist. The basal beds of the Conestoga are so variable that no consecutive section has been recognized for any distance, a fact that made it very difficult to distinguish the formation from the limestone on which it rests and to draw its boundary with certainty at many places. The characters of the basal beds of the Conestoga vary with the formation on which they overlap and from which they were largely derived.

West and north of Welsh Mountain the section is continuous from the Vintage dolomite up to the Beekmantown limestone with no indication of Conestoga type of sedimentation, and as the Conestoga is known to unconformably overlie the Ledger, it is believed to be younger than the Beekmantown. A few brachiopods and crinoid plates and stems recently found by the writers in the lower beds of the Conestoga limestone east of York, Pa., have been identified by Ulrich as forms found in the Frederick limestone of Frederick Valley which is probably of Chazy age. The Frederick limestone also somewhat resembles the Conestoga limestone in appearance and they are probably in part equivalent, but the greater thickness and extent of the lime-stones to which the name Conestoga is applied are believed to warrant a separate formation name. The Frederick limestone rests on Beekmantown limestone in Frederick Valley and the Cocalico shale rests on the Beekmantown northeast of Lancaster. The Conestoga limestone, which is an argillaceous limestone with many shaly beds, may therefore be in part the southeastward representative of part of the Cocalico shale.

[3] C. D. WALCOTT. U. S. Geol. Survey, Bull. 134: 17–19. 1896.

It is concluded, therefore, that in post-Beekmantown time, preceding Conestoga deposition, the southern part of the area was uplifted and the older formations were successively exposed by erosion from the Ledger dolomite near Lancaster to the Harpers schist at Mine Ridge, and that the Conestoga formation was then laid down across the eroded edges of these formations, the waste from the respective underlying formations being incorporated in its basal beds.

SCIENTIFIC NOTES AND NEWS

Dr. LEWIS M. HULL, who for several years has been engaged in studies of electron tubes in the radio laboratory of the Bureau of Standards, has resigned to accept a position as Director of Research of the Radio Frequency Laboratories, Inc., of Boonton, N. J.

E. A. SCHWARZ received the honorary degree of Doctor of Philosophy at the commencement exercises of the University of Maryland on June 10.

NORMAN SNYDER, a member of the scientific staff of the Radio Laboratory of the Bureau of Standards, left the Bureau June 1st for a leave of absence of several months. During this time Mr. Snyder will be with the Research Laboratory of the General Electric Co. at Schenectady, where he will work on electron tube problems.

PAUL C. STANDLEY, of the National Museum, returned to Washington in June from several months' botanical collecting in El Salvador and Guatemala.

Dr. KNUD STEPHENSEN of the Zoological Museum at Copenhagen, well known for his biological survey of the Brede Fjord in southwestern Greenland and for his studies on the Crustacea, accompanied by Messrs. TAANING and OLSEN, recently visited the National Museum.

Dr. RICHARD C. TOLMAN has resigned as director of the Fixed Nitrogen Research Laboratory to take a position in the California Institute of Technology. He is succeeded by Dr. F. G. COTTRELL.

E. D. WILLIAMSON, of the Geophysical Laboratory, left Washington in July to attend the meeting of the British Association, where he will present a paper on the high pressure work of the Geophysical Laboratory.

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ZOOLOGY.—*The possibility of control of* Heterodera radicicola *and other plant-injurious nemas by means of predatory nemas, especially by* Mononchus papillatus *Bastian.*[1] G. STEINER and HELEN HEINLY. (Communicated by N. A. COBB.)

I. INTRODUCTION

The investigations, the results of which are described in this paper, were carried on from December, 1921 to the end of May, 1922, in the Osborn Zoological Laboratory of Yale University, in collaboration with the U. S. Department of Agriculture. The work was outlined by Dr. N. A. Cobb of the Bureau of Plant Industry. As the investigations were of a novel nature, numerous methods for the rearing of nemas had to be worked out. A large quantity of soil-material was collected and washed by a combination of the sieve method described in an earlier paper by Cobb (7) and the well known gravity-method. The daily control of the cultures, transferring the predatory nemas to fresh conditions, keeping records of the victims and adding a fresh supply of food requires much time and patience. *Heterodera radicicola* material was kindly sent to us by the Connecticut Agricultural Station and from the Plant Introduction Garden of the Department of Agriculture, Brooksville, Florida. We wish here to express our appreciation for this assistance. We feel indebted to the authorities of Yale University, particularly the Osborn Zoological Department, for their permission to carry on our work and for their cordial cooperation.

II. THE PROBLEM

Numerous methods of control of plant injurious nemas have been described in the past. Although some of these methods are very useful, yet the fact remains that today the damage done by nema-pests is enormous and is still increasing.

In recent years the study of free-living nemas has been greatly increased, and as a result the problems connected with nema-pests

[1] From the Osborn Zoological Laboratory, Yale University, New Haven, Conn., in collaboration with the U. S. Department of Agriculture. Received September 9, 1922.

have acquired a new aspect. It was shown by Cobb (4,5,6), Menzel (13) and other investigators that there are in the soil certain species, and even whole genera, of nemas, which in some cases are, and in others may be, predatory and doubtless at least occasionally, are feeding on other kinds of nemas, and even species known as nema-pests. Cobb recorded a series of such observations (4) and suggested first the possibility of using these predatory nemas as a means of decreasing the number of plant injurious nemas in the soil.

In a more recent paper Dr. Menzel (13) compiled all the recorded facts and observations on food and feeding habits from the literature on free-living nemas. He performed also some experiments with a species of *Mononchus*, corroborating the observations of Cobb. He observed that *Mononchus papillatus*, brought together with *Tylenchus sp.*, *Plectus auriculatus*, *Tripyla media* and *Anguillula aceti*, attacked these forms, and killed them either by sucking out their vitals, or by swallowing them whole.

Cobb therefore advocated an investigation of the relationship between predatory *Mononchus* species and other soil-inhabiting and plant-infesting nemas, especially *Heterodera*. If possible the investigations should show to what extent the above mentioned facts regarding the feeding habits of some mononchs are a true expression of the life habits of these animals. If they prove to be a true expression, methods for the propagating and rearing of *Mononchus* should be studied with the view to applying the results for practical purposes in agriculture, especially for fighting the root-knot nema, *Heterodera radicicola*.

The first thing for us to find out was the life history, food, and feeding habits of the predatory mononchs. We chose for our investigations *Mononchus papillatus* Bastian, a species which appeared to be best fitted, first because it seemed one of the easiest to obtain, being among the commonest of mononchs, and second because many observations have been made on the voracity of this form.

Recent investigators (1–3, 8–12 and 14–18) have reared free-living nemas, but as far as we know, mostly forms which feed on decaying matter, and therefore in most cases easily reared in a small amount of suitable medium on slides or in watchglasses. Berliner and Busch and also Byars were the first who used agar as a culture medium for true soil nemas, although the nemas they experimented on were plant-parasites, namely: *Heterodera schachtii* and *Heterodera radicicola*. They planted seeds of oats, etc. on agar and then nematized it with eggs and larvae of *Heterodera*.

There have been seen no published statements made concerning the culture of predatory soil nemas. Menzel seems to have kept *Mononchus papillatus* specimens for only a short time in a small amount of water, simply in order to perform his experiments on their feeding habits. Therefore, it was first necessary to invent simple and practical methods for rearing mononchs.

III. METHODS OF CULTURE OF MONONCHUS PAPILLATUS BASTIAN

The greatest difficulty in rearing minute soil organisms, especially soil nemas, is to devise a culture medium permitting at any time the study and inspection of the reared animals and offering as far as possible natural conditions. Soil, however, even in small quantities, is not transparent. If then, the organism to be cultured is to be continuously observed, ordinary soil cannot be used as a culture medium.

A. Culture in a drop of water on a concave slide.—The first attempt to rear the mononchs was in a small drop of water on a concave slide. *Mononchus papillatus* specimens at different stages of growth were isolated in water-drop cultures, and *Heterodera* larvae, different species of *Rhabditis* or *Anguillula aceti*, added as food. By this method it was possible to keep mononchs alive for from one to three weeks, if the water was changed daily. In cultures of this sort the mononchs seemed to remain in very good condition for several days; they were easy to observe and study, and it was not difficult to get a record of the number of nemas eaten or destroyed by them. However, after a short time had elapsed, all animals reared in pure water cultures became sluggish and finally died.

B. Culture on concave slides with soil and water.—After a number of failures with the foregoing method, we tried to get more natural conditions by adding small quantities of soil to the drop of water on the concave slide. It was seen immediately that the nemas under such conditions grew better, and could be kept alive for a much longer time. After some experience, we were able to rear the mononchs by this method from the first larval stage up to the adult stage and even to the point of producing eggs. The following points should be kept in view.

1. In order to render the observations comparatively easy, only a small quantity of soil should be used. A larger amount of soil furnishes a much better medium for the nemas, but the investigator will have difficulty in finding and controlling them. By trials, any investigator can find the best amount of soil.

2. The nature of the soil is not of great importance. Our experi-

ments showed that sandy soil as well as other kinds may be used.

3. It should be seen to that the soil be free from decaying matter.

4. If possible the water, and even the soil, should be changed daily. *Mononchus papillatus* seems to be very susceptible to any pollution, especially bacterial (*B. subtilis* typ.).

It seems very astonishing at first that the simple addition of a small amount of soil should be of such great importance to the growth and life of these nemas. It was found that soil was absolutely essential for the keeping alive of newly hatched larvae and for rearing them.

C. The agar-culture method.—In 1914 Berliner and Busch described a method for rearing *Heterodera schachtii* Schmidt on agar plates. Agar was carefully washed, sterilized and poured into petri dishes. Sterilized seeds of oats, turnips, beets and different varieties of vetch and clover were planted on the agar and eggs or larvae of *Heterodera schachtii* added. This seemed to be a very simple and useful method also for our purpose, it being only necessary to add the mononchs to get a complete food cycle,—*Heterodera* feeding on the roots of the growing plant and *Mononchus* feeding on *Heterodera*. Byars in 1914 also described a similar method for rearing *Heterodera radicicola*. Had good results been obtained, it would have shown very beautifully the relationship between these two forms of soil nemas; but difficulties soon arose. In the first place *Heterodera radicicola*, the form used for infecting the roots, did not attack them (oats, cucumbers) and up to the present time our experiments along this line have not been satisfactory. The mononchs were already feeding on the *Heterodera* and seemed to thrive in the agar, moving constantly around, even laying a number of eggs. So we added more food for them, consisting of *Rhabditis pellio*, *Rh. elegans*, *Anguillula aceti*, and *Heterodera radicicola*. By this time the bacterial infection of the plate grew so heavy that the mononchs died. Young larvae already hatched from the eggs also died, even in freshly prepared and non-infected agar. Thus it seems to us that the agar method may be used only for larvae a week or more old, and adults, and then the agar should be changed every eight to fourteen days.

A further inconvenience consisted in the size of the plate, since on even the smallest plates it was quite difficult to find the nemas and eggs again, because of the rapid wandering of the former through the agar and the minuteness of the latter.

The second method, that of using concave slides with a small quantity of soil in a drop of water, seemed best fitted for our purpose,

especially in the matter of keeping records of the rate of growth and the number of animals destroyed.

D. *The tube-culture method.*—Desiring to control the results of our slide cultures, we started, after several other experiments, with cultures in a larger amount of soil in small glass tubes, which were placed in holes bored in a small block of wood, as shown in Fig. 1. A small

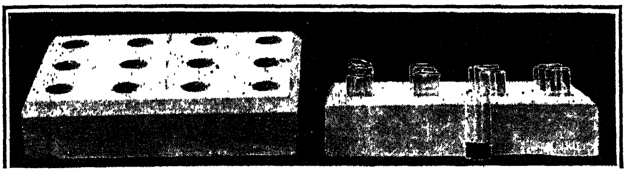

Fig. 1. Wooden block and glass-tubes with soil contents illustrating the tube-culture method of rearing mononchs.

amount of sterilized soil was placed in each of these tubes, moisture added, as well as the mononch to be reared, and a daily supply of *Rhabditis*, *Anguillula* or *Heterodera* as food. The tubes were kept in a moist chamber. If a large amount of soil was used it was not necessary to renovate the tubes for several weeks, but if a smaller amount was used, a weekly change was required. The chief aim was to secure conditions for the mononchs as near as possible to those found in the soil of fields.

Under these conditions it was possible to rear *Mononchus papillatus* in a shorter time than on concave slides. A larger number of eggs was also produced. If a sufficient amount of food was added, numerous mononchs could be reared together in the same tube, without their attacking each other.

The best method for inspecting a tube was to pour the contents into one or more large watchglasses and then dilute with a large quantity of water. If this was not done, eggs and larval forms easily escaped notice.

E. *Remarks on flower-pot and field experiments.*—Finally a series of host-plant experiments were also performed. Flower pots and soil were sterilized in an autoclave, and sterilized seeds of oats, tomato and cucumber, planted. The seeds were sterilized according to the presoak method, a one-tenth per cent solution of commercial formalin being used. After the first roots were formed and the growth began, the plants were infected with a certain number of *Heterodera radicicola* and also *Mononchus papillatus* added at the same time. Unfortunately

we worked with too small a supply of animals, and could not get noticeable results within the short time available. The roots were attacked by *Heterodera* but the effect of the *Mononchus* was not determined. With further experiments along this line, it should be quite possible to observe results from the external appearance of the host plants.

IV. THE LIFE-HISTORY OF MONONCHUS PAPILLATUS BASTIAN

Comparatively little is accurately known about the life-history of free-living nematodes. About the only forms that have been studied are those living on decaying matter, such as species of *Rhabditis*, *Cephalobus*, *Plectus* and *Diplogaster*. Most of these genera have a very rapid development and are in this way somewhat adapted to the ephemeras of dead and decaying bodies that serve as food. From a study of these forms it would be impossible to generalize and state that all soil or free-living nematodes have a rapid development and short life. The results we obtained in rearing *Mononchus papillatus* showed that the life of this form may be of considerable length, and the same thing may be true of many of the other soil nematodes.

In order to judge the value of *M. papillatus* for fighting other nematodes it is necessary to have a complete knowledge of its life history, the time required to reach the adult stage, the number of eggs produced and the length of life after the cessation of egg production.

Nematodes live in the soil as members of an association of living forms, among which there exist interrelationships. It is important to know what effect *Mononchus* as a predatory form may have on the associated nematode population of the soil, and especially its influence on the diminution of forms causing root-knot and similar diseases; if the monoch has a high rate of propagation, and lives for a long time, it has naturally a more rapid and beneficial effect.

A. The hermaphroditism of Mononchus papillatus.—Hermaphroditism in numerous species of the genus *Mononchus* was first observed by Cobb. Males have been described in very few species, and seem to be extremely rare in most of them. A gradation exists in this genus similar to that found in the genera *Rhabditis* and *Diplogaster*, where we find some species in which there is an equal number of males and females, some in which from ten per cent to forty per cent or more are males, some species in which not even one per cent are to be found and still others in which males seem never to occur.

Conditions similar to these are found in the genus *Mononchus:* the Antarctic *M. gerlachei* seems to produce an equal number of males

and females,—males are rare in *M. obtusus* and in most of the species they have not yet been found.

Hermaphroditism in *Mononchus papillatus* is of some importance in our problem, as every individual is able to reproduce, not being dependent upon the presence of the other sex for propagation. This may prove of great value in using this species as a means of fighting injurious nemas.

B. The egg and the embryonic evolution.—The spermatozoa in *M. papillatus* are very minute, the ovary producing them early, and later on the eggs. Fertilization then takes place. The ovary of the nema is syngonic, and the animal a protandric syngone. (See Cobb 5.) We could not determine the number of sperms produced but it is probably rather restricted, as we observed several cases of old females that formed eggs (at times depositing them also), that were probably not fertilized, as they never developed.

There were never more than two eggs in one uterus at a time, and usually two or three to the individual were observed. It was rather a rare occurrence for the animal to have four eggs, two in each uterus. The eggs were elongated, and appeared smooth shelled in the uterus, but when deposited the surface seemed covered with protuberances, having the appearance of short ridges, the whole surface having a somewhat lace-like effect. (See Fig. 2.)

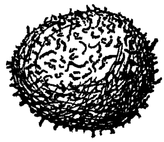

Fig. 2. Egg of *Mononchus papillatus* showing the protuberances on the egg shell.

If the mononchs lived in an approximately normal condition, an average of two or three eggs was deposited daily. Our slide cultures showed a production of two or less, but the tube cultures gave higher results, and it may be that under natural conditions in the soil the egg production is still higher.

In the slide cultures, the maximum number of eggs deposited by one female was twenty-eight in twelve days, the animal then ceasing to produce; but in tubes our records showed eighteen eggs produced in six days, and forty-one larvae hatched from eggs produced by one female in twenty days were also found. The exact number of eggs produced may have exceeded this, as even with the most careful inspection, eggs and larvae may escape notice. Experiments along this line are still being carried on and higher figures may be obtained.

The number of eggs laid by one *M. papillatus* seems very small when compared with that of some other free-living species, as, for instance, species of *Rhabditis*, in which within a few days eight hundred or more

eggs are produced. The maximum number obtained from one *Mononchus* was forty-one, the minimum number, twenty eggs.

The eggs required from six to seven days before hatching. This also is rather a long period compared with *Rhabditis*, *Diplogaster* and some other known forms. The mononch eggs are unicellular when deposited; the first division takes place about twenty-four hours later.

C. The development of the larva of Mononchus papillatus.—The newly hatched larva is very active but not hardy, and the presence of soil seems very essential to its life. The body is quite transparent. As far as our experiments show, during the first two or three days the larvae attacked no nemas; but on the fourth day, and even on the third day, the predatory instinct was developed and they began to feed on other nemas. As soon as this occurred the intestine began to darken and in a short time became opaque.

The time of larval development up to the period of sexual maturity was somewhat varied. Slide cultures showed the average time for larval development (from the end of embryonic life in the egg shell to sexual maturity) to be from six to seven weeks. But tube cultures showed the minimum time to be only four and one-half weeks. The temperature of these cultures was the same, and the difference in results must be due to the more natural environment found in the tubes. Therefore we are inclined to adopt the minimum time as the time required for development, and to judge from this the influence of this species upon the nematode population of the soil.

Unfortunately, up to the present, we have not been able to get exact data as to the time and number of the moultings. We observed three moults, two in the earlier stages of growth and one just before arrival at sexual maturity. In a study of the life history of one specimen we observed a moult at eighteen days and another at forty-four days after hatching, the latter being the moult just before sexual maturity. Judging from the size of the nema at which other moultings were observed, there must be a moult between eighteen and forty-four days. There may be a moult soon after hatching, but we never observed it. The skin is shed as a whole. There were no observations of the act of moulting, but, judging from the cast, the animal leaves the skin through an opening in the ventral side near the cardia. The mouth-capsule and wall of the rectum were found attached to the cast; the lining of the oesophagus was not observed and may be cast off separately. The animal became rather sluggish and inactive just before each moult.

D. The adult and senile Mononchus papillatus.—Soon after moulting the last time, the mononch began to produce eggs. At this age, the nema was extremely voracious. The number of eggs produced seemed to be in direct proportion to the number of destroyed and devoured nemas.

The maximum duration of egg production observed was twenty days, but further experiments may probably show a longer period.

The period after the cessation of egg production was called the senile stage. It seemed very remarkable that this senile stage was of such long duration as compared with the length of the other periods. In one case the senile period lasted ten weeks, while the combined length of the other periods was only eight weeks. In many hermaphroditic nematodes there are long senile stages. The senior author observed in cultures of the hermaphroditic *Rhabditis elegans* Maupas, the length of the different life periods to be as follows:

April 20—newly hatched larva,—(larval stage lasted two days or less).

April 24—first production of eggs,—(egg production stage lasted two to three days).

April 26—production of eggs stopped,—(senile stage lasted thirteen days).

May 9—death.

Of a life period of eighteen to nineteen days, thirteen were of the senile stage, that is, the period after the last fertilized egg was laid. The senile stage was therefore two or three times longer than the other life periods taken together. The protandric syngonism (Cobb 5) of these forms is probably the cause of this. If spermatozoa are essential and only a certain number of spermatozoa are produced, then when this supply is exhausted, if the gonads are unable to produce more sperms, all subsequent ova will fail of further development, and senility begins.

The same thing seems to happen in *Mononchus papillatus*. The comparatively enormous length of the senile stage may be the result of the inability of the syngone to produce sperm cells a second time. The senile period of ten weeks was observed on a slide culture, and under more favorable conditions it may last very much longer.

In judging the relationship between *Mononchus papillatus* and other soil nematodes the above facts are of some importance, as the amount of food required during the senile stage was very small compared with that devoured during the egg-producing period. Consequently all

senile *M. papillatus* have a decreased efficiency in combating nematode pests.

V. LENGTH OF LIFE OF M. PAPILLATUS

Eighteen weeks was the maximum length of life observed for *M. papillatus* in a slide culture; the tube culture method showed the life period under more normal conditions to be very much longer. Compared with the length of life of other nemas, even excluding forms of *Rhabditis*, *Diplogaster*, *Plectus* spec., etc. that live on decaying matter, this period seems very long, but it may not be exceptional for soil nematodes. At the Zoological Station of Cette (France) the senior author kept adult marine nematodes alive for a comparatively long time, as for example an adult species of *Thoracostoma* for over thirty days. We may therefore conclude that free living nematodes have a much longer life period than is usually supposed.

To a certain degree, this fact may compensate for the restricted number of eggs of *M. papillatus* when considering the effect of this species on the nema population of the soil and the whole community of life therein, as, it means an increase of the efficiency of this species as a destructive factor.

VI. FOOD AND FEEDING-HABITS OF M. PAPILLATUS

In working out our problem, a study of the food and feeding habits was of the greatest interest. From statements made by the investigators already mentioned, it was known that *M. papillatus* fed on other nematodes. It was necessary to discover whether the carnivorous habit lasted throughout its life or for only a certain period. To obtain these facts was of great importance as they determined largely whether *M. papillatus* can become a really efficient agent in combating nematode pests. Our experiments along this line confirmed fully what Cobb in several papers stated to be true. In our cultures, *M. papillatus* lived exclusively on other nemas, also appearing at times to devour small soil particles. The consumption of soil grains seemed to be of chief importance in the first larval stage of the animal, and we observed likewise in the intestine of adults soil particles of unknown origin. The important influence of the presence of soil on our cultures seemed also to confirm these observations.

The larval *M. papillatus*, just hatched from the egg, was very active. Its intestine at first was transparent; the cells of the thin wall at this stage were easily seen, and their nuclei as well. But in a suitable medium, a few days were sufficient to transform this colorless intestine

into a brownish, or even apparently black organ. To this end the presence of soil was absolutely necessary. In water, but with plenty of food (other small larval nematodes) the mononch larvae remained transparent and died in a short time. We were not able to determine exactly what kind of food the newly hatched and very young larvae ate. They moved through the soil, sucking here and there on soil fragments, and particles of an organic nature were probably consumed. But the mononch larvae soon began to feed on other nematodes. We observed three-day old larvae feeding on *Rhabditis* larvae, and their voracity increased with their age.

Our records showed that the number of nematodes killed daily in-

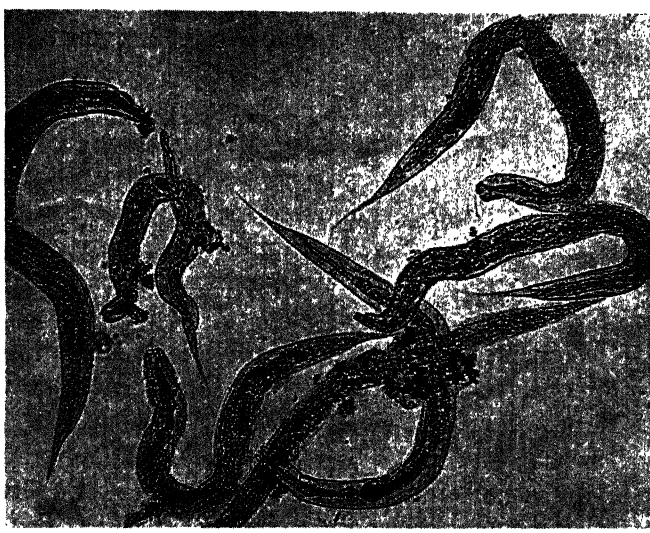

Fig. 3. Photograph of the dead bodies of *Rhabditis elegans* Maupas as they appeared after their slaughter by mononchs. The picture shows well the common method of destruction, that of piercing the cuticle and sucking the contents of the body in the manner of a weasel.

creased as the mononch developed, beginning with one or two destroyed during the third or fourth day of larval life, and attaining a maximal number of sixty-five. In one case as many as eighty-three *Heterodera radicicola* were killed (either swallowed wholly or partly sucked out) by one mononch in one day. The largest amount of food was consumed at the time the maximal number of eggs was produced, and then it decreased during the senile stage of life. During a life time of about twelve weeks one animal killed 1332 nematodes. We are certain

that this number may be very much larger under natural conditions. It was also observed that during the moulting periods fewer nematodes were killed and for a period of one or two days none at all, with a decided increase after the moult.

When in a resting position, the mononch lay on its side, and never on either its back or "stomach." The body was more or less curved ventrally,—the tail end often bent in the form of a spiral. At times the whole body was spirally curved. Agar was the best medium for the study of the movements. It was seen that locomotion was accomplished by bending in the dorso-ventral plane of the body, this plane being placed mostly in a horizontal position so that the dorsal and ventral sides were seen in profile. *Mononchus papillatus* changed continually from a moving to a resting state, moving backward as well as forward.

In the water-drop cultures with a small amount of soil, the mononchs were found only very exceptionally outside the soil area. There was a striking difference in the behavior of *Mononchus papillatus* and the *Rhabdites* added as food. The mononchs seemed to have a more highly developed stereotropism, as they remained well hidden in the soil, while the *Rhabdites* were more or less concentrated on the edge of the water drop outside the area occupied by the particles of soil.

The sense of touch seemed to be the only sense *M. papillatus* used in hunting about for food. It is known that in nematodes three different kinds of sense-organs may be developed.

1 *Organs for the sense of touch.*—These are no doubt among the chief sense organs of the group and show a high degree of perfection in stereotropic reactions and reflex movements.

2 *Chemical or chemico-physical sense organs,*—those known as lateral organs or "amphids." In *M. papillatus* the amphids are rather small and inconspicuous.

3 *Organs for the perception of light.*—These are found in many free-living nematodes, but are absent in mononchs as well as in most soil inhabiting forms.

Judging from the behavior of *M. papillatus,* the organs of touch were probably the only ones used while hunting for food. The nema moved through the medium, continually searching its surroundings by moving the head end in all possible directions. The head end contains the chief organs of touch, as well as those for chemical perception. After long observations, we came to the conclusion that *M. papillatus* was not able to find its prey at long distance, and the use

of the sense organs of touch seemed to be its chief method of locating food. We could therefore confirm statements made by Menzel about this matter.

As soon as the head end of a mononch came into contact with its prey, it grasped it tightly. By a sucking movement, probably of the oesophageal muscles, the head was fixed to the prey. The nematode caught by the mononch naturally made most violent efforts to get free, and often the mononch was shaken and dragged along. But it held on tightly and soon its tooth and other mouth parts began to work. By a sucking movement of the oesophagus and mouth cavity, the mononch became more firmly fixed to its prey, when the tooth located on the dorsal wall was protruded and produced an opening in the skin of the victim. Then a stronger (or further) sucking action was exerted by the mononch and the tooth came back to its normal position. The whole oesophagus came often into action and moved forward and backward with the intestine, the whole body going through the same movements; first the body fluid of the prey was sucked out, and as this happened its body became shrunken. Very often the mononch was satisfied with this, and set free its prey, which died shortly afterwards. Specimens of *Rhabditis elegans* killed in this way are pictured in Fig. 3.

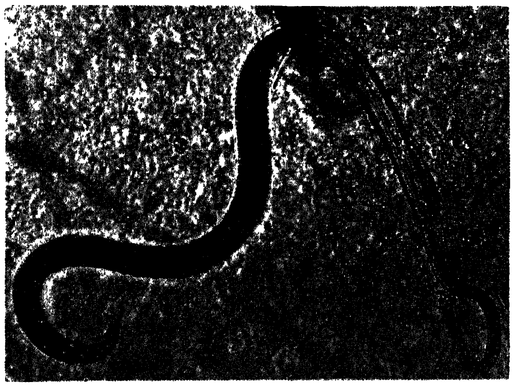

Fig. 4. Photograph of a mononch attacking an *Anguillula aceti* near the cardia. Photograph taken from an agar-plate.

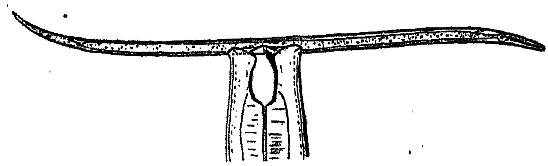

Fig. 5. Sketch of the head-end of a mononch attacking a larval *Rhabditis*. Notice the wide opened lips and the protruded tooth.

M. papillatus rarely devoured an entire animal when feeding on large forms, except when exceedingly hungry. No one part of the victim's body seemed to be preferable for attack, the prey being seized at random. Fig. 4 shows an *Anguillula aceti* attacked near the cardia, and

Fig. 5–9 in other situations. Larval mononchs were only able to attack and destroy the prey in the way described, but even a small mononch will attack prey of much larger size. Large mononchs often swallow smaller nemas whole; this will happen, if the prey is seized at one end of the body, the animal being then sometimes swallowed without being killed or even injured by the mouth organs of the mononch. In our slide cultures this phenomenon was twice observed. A large adult mononch swallowed a rather large larva of *Rhabditis elegans*. In this species of *Rhabditis* the larvae are very slender and more resistant than other species. The larva seemed to have passed through the mouth and oesophagus of the mononch without harm, probably in the way sketched in Fig. 10. We first noticed that the mononch, very active the day before, appeared nearly motionless. To our great astonishment we noticed the larva of the *Rhabditis* moving throughout the intestine as if searching everywhere for an exit. The larva moved in every possible direction, the mononch becoming less active all the time. We were very interested in knowing the outcome of this case. The digestive fluid in the intestine of the mononch did not seem to harm the larva. The same evening, the mononch did not react to outside stimuli and appeared quite motionless. During the night the *Rhabditis* found a way to freedom through the vulva opening, and in the morning the mononch was dead. The same thing happened shortly afterward with another very active mononch.

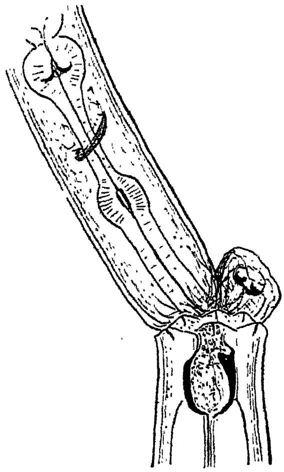

Fig. 6. Sketch of the head-end of a mononch seizing an adult *Rhabditis* by the neck. The skin of the prey is already opened, and the mononch is sucking the contents; notice that the dorsal tooth during this sucking action is in its normal position and not protruded. The prey was afterwards sucked out as shown in Fig. 9.

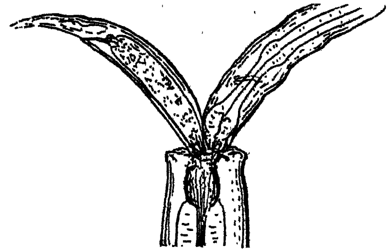

Fig. 7. Sketch of a *Rhabditis* seized near the middle of the body and partly sucked. See Fig. 8 for later stage.

From a scientific point of view these incidents are of interest, as they show that this species of *Rhabditis* is very resistant to mononch

digestive fluids, and they also throw light on the way the mononch swallows, and the action of the dorsal tooth of the mouth cavity. Incidents of the kind just described seem only possible if the tooth, during the act of swallowing, is protruded to such a degree that its point cannot harm the prey. Very probably, the latter was caught by the tail-end, and in the act of seizing, the tooth was protruded and the tail glided into the mouth cavity. In most cases the prey is seized at some other part of the body as Figs. 7–8 show. In this case not only the body fluid is sucked out, but also a large part of the intestine. Fig. 8 shows the prey after release, the skin remaining.

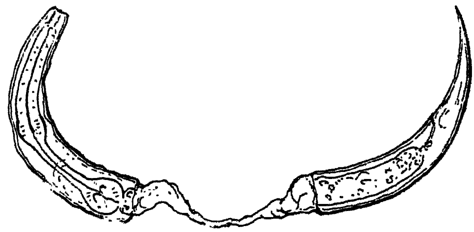

Fig. 8. The *Rhabditis* refered to in Fig. 7 as it was released after having been partly sucked. Notice that the skin of the emptied part remained.

The chief organ of the mononch functioning during the act of swallowing was undoubtedly the oesophagus. The contractions of its radial muscles were vigorous; they began at the mouth cavity and ran down the oesophagus so quickly that at first they seemed instantaneous. But more careful observations showed that each contraction first began around and behind the mouth and then ran back to the intestine. This contraction of the oesophageal radial muscles was accompanied by a shortening of the entire organ, and the whole intestine during the act of swallowing moved back and forth. As soon as the radial muscles contracted, the oesophagus apparently shortened and the forward movement of the cardiac region was easily seen. When contraction ceased, the oesophagus assumed its normal shape and the cardiac region and intestine moved backwards.

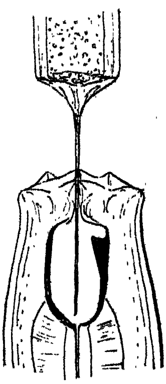

Fig. 9. Sketch of a *Rhabditis* sucked out completely at one end, notice the remaining skin.

The mouth cavity did not serve as a place for macerating food, but more or less as a suction capsule. Together with the lips and the attached muscles, it may seize and retain the prey, but our knowledge of the whole apparatus was not sufficient to completely understand its function. The dorsal tooth was certainly protruded as long as the whole cavity was used in retaining the prey.

Some of the digestive fluids are probably formed and secreted by small glandular cells among the radial muscles of the oesophagus. These glands were first described by Cobb. Their secretions may not act in the oesophagus itself, as the food did not stay there. Digestion began and ended in the intestine. The oesophageal glands were probably compressed every time the animal swallowed by the shortening and pressure of the radial muscles, and the digestive fluid thus entered the intestine with the food.

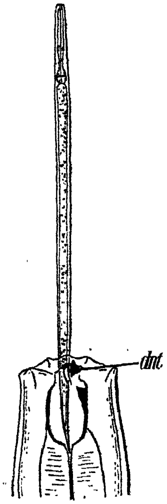

Fig. 10. Sketch of the supposed manner of swallowing the *Rhabditis* larva which was found living and moving in the intestine of a mononch, killing it afterwards by breaking through the intestine and body wall. *dnt.*—tooth as it is supposed to have acted during the attack on the larva.

VII. MONONCHUS PAPILLATUS AS A FACTOR IN FIGHTING NEMATODE PESTS

The foregoing experimental results show conclusively the predatory nature of *Mononchus papillatus*. From our experiments, and from observations made by other investigators, all kinds of nematode species, and Rotifers, Naididae (small Oligochaetes), etc. are taken as food. *Heterodera radicicola* is acceptable in large numbers, and we were able to rear *M. papillatus* by feeding this form of plant-injurious nema exclusively. The same thing happens in the soil and there is no doubt but that mononchs live there in about the same way as in our cultures. Undoubtedly this predatory nema when present kills *Heterodera* and other injurious forms in soil planted with crops. It is therefore extremely useful and its propagation should be encouraged. Under some conditions this form perhaps completely controls *Heterodera* and similar plant-injurious species. Why should this not become the case in our infested fields? Further investigations should be started along these lines.

Once in the roots, *Heterodera* and other such root-parasites are probably protected against the predatory mononchs, but when moving freely in the soil during larval life, they may be destroyed in large numbers and we are convinced that under favorable conditions *Mononchus* is able partially, perhaps completely to control some of these destructive forms. In order to advance any further along this line, it is absolutely necessary to have a knowledge of the nematode population of different kinds of soil, of the relationships that exist

between these forms and other members of the community of living forms that exist there, and of their relationships to other nematode species.

VIII. THE SOIL, ITS LIFE AND THE NUMBER OF NEMATODES, ESPECIALLY OF PREDATORY FORMS THEREIN

Our knowledge of life in the soil, especially of microscopic life there, is still very restricted. We know very little about the relationships that exist between the living components of the soil, and often we do not even know these components. Certainly soil fertility does not depend entirely upon its chemical, colloidal and physical nature, but also and probably largely, upon the animal and plant life therein. The importance of soil bacteria is already known and there exists a close relationship between these bacteria and the nematode population, as a large number of nemas are bacteria consumers. Investigations carried on throughout more recent years have definitely proved that the soil contains an enormous number of nematodes, and that, next to bacteria, they form probably the largest constituent element in subterranean life. Numerous new species have been described and all investigators agree that there is an enormous number still undescribed. It will require the collaboration of many research workers to describe all these forms. A nema species may furnish millions of individuals to every acre of our fields. No exact records regarding the number have been published so far. Dr. Cobb kindly placed at our disposal some of his tables from field surveys. The results of the surveys shown below are of great interest.

	Minimum number of nematodes per acre, top six inches (15.2 cm.)
From Missouri corn field	648,000,000
From North Carolina field	242,400,000
From New Jersey field	129,600,000
From Rhode Island field	610,800,000
From New Hampshire field	99,600,000
From Minnesota field	121,200,000
From Vermont field	580,000,000
From Kansas field	278,400,000

These tables give only the minimum numbers and are figures taken from a study of only the top six inches (15 cm.). A maximum penetration of some nema species has been observed to be as much as (7–8 m.) 25 feet. These unpublished observations were made by Dr. Cobb on citrus trees in California and on alfalfa roots in New South Wales.

Usually soil nematodes go as deep as the roots of plants can penetrate and therefore the depth figures recorded in publications are too small.

Until recently nemas have been almost completely disregarded by investigators of soil economics, and especially by research workers in soil fertility.

If we wish to know what part nematodes play in the economics of the soil, one of the first questions to be answered is what is the nature of their food. There have been no very comprehensive studies made of this question up to the present, and our knowledge is based mostly on only occasional observations. The results of these show that some forms such as *Rhabditis*, *Cephalobus*, etc. feed on decaying matter, that is on the contained bacteria or bacterial products; others, such as *Tylenchus*, *Heterodera*, *Aphelenchus*, etc. feed on plant tissues or fluids; others such as *Dorylaimus*, etc. feed probably on both plants and animals; and still others such as *Mononchus papillatus*, described in this paper, are apparently exclusively predatory. So that not only the problem of combating nematode pests in soil by the use of their natural enemies will be attacked by investigations along this line, but also the problem of soil fertility itself.

Today we know that soil nematodes play a very important role,

1. As consumers and destroyers of our crops;—often destroying whole fields, but much oftener decreasing their yield in a less perceptible degree.

2. As consumers of, and as important workers in the distribution of the bacterial flora of the soil. Their activity is certainly not restricted to denitrifying bacteria, but extends to nitrifying forms as well. A closer study may show relations of very great importance. They carry bacteria and fungus spores everywhere. Wounds on roots or other parts of plants may very often be infected by bacterial and fungus diseases carried by these nematodes. (See Metcalf 15.)

3. As having relationships with fungi upon which some species are known to feed. According to Zopf fungi on the other hand may use nematodes as prey.

4. As consumers of protozoa. It is known that certain fresh-water nemas feed specially on protozoa, sometimes apparently on a single species. There is a probability that some soil species may feed in a similar way, and further investigations may enable us to combat plant injurious protozoa by the use of these nemas.

5. As furnishing a control for plant-injurious nemas. This refers to the work of predatory nemas, such as *Mononchus papillatus*, whose

feeding habits have been described in this paper. There are other species of nemas with a similar significance. Here is a great field for study. Investigations should also be carried on to show more definitely the relations of these predatory forms to rotifers, oligochaetes and other soil animals.

6. As a factor in the humification of the soil, in transformation and removal of all kinds of organic matter, decaying bodies, etc.

7. As assisting in the aeration of the soil. We know how very important aeration of soil is for the growth of bacteria and all kinds of plants. Quite possibly these millions of nematodes living in the soil are highly useful aerators.

In order to solve the problem of the relation of soil nemas to soil fertility, we require a knowledge of the nema population in the soil itself and we also need to know:

1. The composition of the nema population, the species found and their numeric representation in all kinds of soil,—sandy, humus, swampy, dry-soil, hard clay, etc.

2. The horizontal and vertical distribution of nemas in all kinds of soil and the reasons for this.

3. The seasonal changes of the different species, the number of species and the number of individuals of each species.

4. The influence of habitat on the nematode population including physical, chemical and biological factors found in the habitat. The biological factors include kinds of crops and other forms of vegetation that may be present.

The working out of these problems will surely enable us to conclude why nema pests are absent in some cases, and why in apparently similar conditions they exist in such enormous numbers. A large field is thus opened up for investigations, the results of which will be of great importance to agricultural science.

REFERENCES

1. BERLINER, ERNST and BUSCH, KURT. "Über die Züchtung des Rübennematoden (*Heterodera schachtii Schmidt*) auf Agar." Biol. Centralblatt **34**: 349. 1914.

2. BYARS, L. P. "Preliminary notes on the cultivation of the plant parasitic nematode, *Heterodera radicicola*." Phytopathology **4**: 323–326. *pl. 21.* 1914.

3. BYARS, L. P. "The nematode disease of wheat caused by *Tylenchus tritici*." U. S. Dept. Agr. Bull. **842.** 1920.

4. COBB, N. A. "The Mononchs. A genus of free-living predatory nematodes. Contributions to a science of Nematology VI." Soil Science **3.** 1917.

5. COBB, N. A. "Notes on Nemas. Contributions to a Science of Nematology V." Waverly Press, Baltimore, 1917.

6. COBB, N. A. "Nematodes of the slow sand filter beds of American cities. Contributions to a Science of Nematology VII." 1918.

7. COBB, N. A. "Estimating the nema population of the soil." Agric. Technology Circ. I, Bur. Pl. Ind., U. S. Dept. Agr. 1918.

8. CONTE, M. A. "De l'influence du milieu nutritif sur le développement des Nematodes libres." Compt. Rend. Soc. Biol. **52**: 374–375. 1900.

9. HILGERMANN and WEISSENBERG. "Nematodenzüchtung auf Agarplatten." Central. für Bakteriologie, Parasitenkunde und Infektionskrankheiten, Originalia, Bd. **80**. 1918.

10. JOHNSON, G. E. "On the Nematodes of the Common Earthworm." Quart. Journ. Micr. Sci. **58**: 605–652. 1913.

11. MAUPAS, E. "La mue et l'enkystement chez les Nematodes." Arch. Zoöl. Expt. III. **7**: 563–628. 1899.

12. MAUPAS, E. "Modes et formes de reproduction des Nematodes." Arch. Zoöl. Exp. III **8**: 463–628. 1900.

13. MENZEL, R. "Über die Nahrung der freilebenden Nematoden und die Art ihrer Aufnahme." Ein Beitrag zur Kenntnis der Ernährung der Würmer." Verhandl. Naturf. Ges. Basel **36**: 153–188. 1920.

14. MERRILL, T. H. and FORD, A. L. "Life History and Habits of Two New Nematodes Parasitic on Insects." Journ. Agr. Research. **6**: 115–127. 1916.

15. METCALF, H. "Cultural Studies of a Nematode Associated with Plant Decay." Trans. Am. Micr. Soc. **24**: 89–102. 1903.

16. OLIVER, W. W. "The Cultivation of an Ectoparasitic Nematode of a Guinea Pig on Bacteriologic Media." Science (n. s.) **36**: 800–801. 1912.

17. POTTS, F. A. "Notes on the Free-living Nematodes." Quart. Journ. Micr. Sci. **55**: 433–484. 1910.

18. WELCH, PAUL S. and WEHRLE, L. P. "Observations on Reproduction in Certain Parthenogenetic and Bisexual Nematodes Reared in Artificial Media." Trans. Am. Micr. Soc. **37**: 141–176. 1918.

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MINERALOGY.—*A worked jade pebble from Copan.*[1] H. S. WASHINGTON, Geophysical Laboratory, Carnegie Institution of Washington.

During his excavations at the ancient Maya city of Copan, Honduras, in 1919, Dr. Sylvanus G. Morley found a flat pebble of jade (sawn in two and perforated), on the platform of Stela 7.[2] (Fig. 1.) The material of this pebble seemed to be of such interest, and its pebble form argued so strongly for an American provenance, that I expressed a desire to study it. I am deeply indebted to Dr. Morley for the privilege of examining the object, and especially for his liberality in permitting me to remove a few grams for the chemical and microscopical study. It is gratifying to know that the mutilation has yielded some results of interest in connection with the study of American jades.

The pebble has had a wide cylindrical perforation bored into it from each flat side, penetrating almost to the center and tapering slightly inward; it was then sawn in two equatorially down the center about half way between the two flat sides, thus freeing the cylindrical cores of the perforations, which (as Morley states) were probably used for making ear ornaments, either disks or plugs.[3] The width of the equatorial cut was about 5 mm.

With this pebble was found a finely worked and highly polished deep green pendant, 7.5 cm. high, representing a human figure, with the arms crossed over the breast; this figure was intended to hang with the side outward. The weight of this is 87.8300 grams, and I found its specific gravity to be 3.307 at 22°, indicating that it is composed largely of jadeite, with but little of the diopside and albite

[1] Received October 3, 1922.

[2] S. G. MORLEY. *The inscriptions at Copan.* Carnegie Publ. **219**: 105. 1920.

[3] Dr. Morley thinks that the perforation was carried through from side to side; but that it extended only partly through from each side is indicated by the slight traces of a ridge at the bottom edge of each perforation extending a millimeter or so inward around the edge. The saw marks show that the sawing was done in various directions and extended down to the perforation, the marks being tangent to this circle.

molecules present.[4] I have not yet had the opportunity to study the material chemically or with the microscope. It is what appears to be the jade most valued among the Maya.

Dr. Morley informs me that "the nearest monument to these objects is Stela 7, recording the date 9.9.0.0.0. of the Maya Era, or 354 A. D. These jades, however, probably date from a century to a century and a half later."

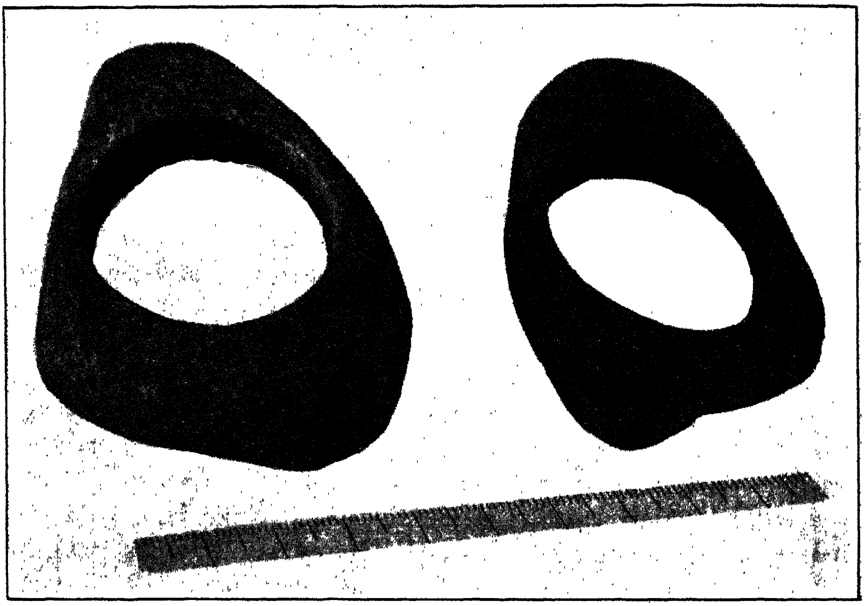

Fig. 1. Worked jade pebble; Copan, Honduras. A on the right, B on left.

The two pieces are not quite the same size or weight, but they are unquestionably parts of the same pebble. Their general form is shown in fig. 1. The greatest length is about 7.6 cm., the greatest width (B) 5.2 and (A) 5.5 cm., while the smaller (A) is about 5 cm. in greatest thickness and the larger (B) about 1.2. The perforation is circular and of the same diameter in each, 3.3 cm. The smaller (A) weighed 37.3062 grams (before the piece, weighing about 3 grams, was removed by me), and the larger (B) weighs 55.8190 grams.

The curved surfaces are those of the original pebble; they are water-smoothed, but not polished. In color the smaller piece (that

[4] See a forthcoming paper on *The jades of Middle America*, to be published in Proc. Nat. Acad. for 1922.

which was analysed) is of a nearly uniform, pale gray green, between Ridgway's pea- and sage-green. The larger is decidedly whitish on the natural surface, which shows slight pitting; and this has evidently been somewhat weathered, as is also shown by its lower density. On the sawn face it is of about the same color as the other. The texture of both pieces is very fine-grained, indeed quite aphanitic. The material shows the lack of toughness which is characteristic of the Middle American jades.

The specific gravity of the smaller piece was determined by me as 2.934 at 19.4°, giving a density of 2.929; while Dr. L. H. Adams obtained the density value 2.932 for the same piece. The true density may be taken as 2.930. Adams found that the density of the larger, whitish piece is 2.756.

In thin section the jade (of piece A) is seen to be composed largely of clear albite in irregular poikilitic patches, not as the sharp anhedral grains or angular interstitial areas which are most commonly seen in other Middle American jades. Through this albite matrix is interspersed, not uniformly, considerable pyroxene, of an extremely faint brownish color, not pleochroic. Some of the pyroxene forms rather large (0.5 mm. long), roughly prismatic grains; much of it is in small (up to 0.3 mm. long), sharp prisms; but most of it is in small irregular grains, which appear to be due to crushing. There is no definite general orientation of the pyroxene crystals, and they tend to be felted where they are most thickly crowded. No other minerals were seen in the section.

Dr. H. E. Merwin kindly determined the refractive indices of the pyroxene and found the values: $\alpha = 1.665, \gamma = 1.693, \gamma - \alpha = 0.028$ These values are close to those of artificial diopside ($CaMgSi_2O_6$): $\alpha = 1.664, \gamma = 1.694, \gamma - \alpha = 0.030$. As will be shown presently this Copan pyroxene is composed of about 71.5 per cent of diopside and 28.5 of jadeite, leaving out of account the probable presence of some albite in solid solution. This is more fully discussed in the forthcoming paper mentioned above.

A chemical analysis was made of a portion of a small wedge (weighing about 3 grams) which was sawn out of the end of (A) the smaller and fresher piece. The analysis, made on material dried at 110°, gave the results in table I.

The analysis of the Copan jade differs widely from those of other jades, from Chichen Itza, and other localities in Mexico, and Central

America, made by me and others, especially in its high silica, rather high magnesia and lime, and low soda. In most respects it is intermediate between the jade of the Tuxtla statuette and that from Chichen Itza shown above. The former is composed entirely of diopside-jadeite (the two being present in about equal amounts), while the latter is about two-thirds albite and one-third diopside-jadeite.

The relations are perhaps better shown when the analyses are recalculated into terms of their mineral molecules.

TABLE I.—ANALYSES OF JADES FROM CENTRAL AMERICA

	1	2	3
SiO_2	62.64	55.50	64.64
Al_2O_3	14.92	12.33	18.83
Fe_2O_3	0.60	1.41	0.46
FeO	1.25	1.33	0.49
MgO	4.31	8.72	1.87
CaO	5.92	12.76	2.62
Na_2O	8.78	6.94	11.25
K_2O	0.23	0.25	0.23
H_2O	1.27	0.30	0.16
TiO_2	none	none	none
Cr_2O_3	none	none	0.07
MnO	none	0.05	none
	99.92	99.59	100.62

1. Jade Copan pebble. Washington analyst.
2. Diopside-jadeite, Tuxtla statuette, Washington analyst. H. S. Washington, Proc. U. S. Nat. Mus. 60: Art. 14. 1922.
3. Jade bead, gray-green. Chichen Itza, Yucatan. Washington analyst.

TABLE 2.—ANALYSES OF CENTRAL AMERICAN JADES IN TERMS OF MINERAL MOLECULES

	1	2	3
Orthoclase	1.12	1.67	1.11
Albite	61.31	none	62.61
Anorthite	0.56	1.67	0.28
Jadeite	10.10	45.25	25.25
Diopside	22.60	49.40	9.85
Hypersthene	1.86	0.50	0.60
Magnetite	0.93	1.74	0.70

Here we note the extremely pyroxenic character of the Tuxtla jade (2), while the Copan (1) and Chichen Itza (3) jades contain about the same proportions of albite and pyroxene. In the Copan jade, however, there is about two and a half times as much diopside as jadeite, while in that from Chichen Itza the relation is almost

exactly reversed. It may be said here, anticipating another publication, that the pyroxene in the great majority of Mexican and Central American jades shows a great preponderance of jadeite over diopside. The pyroxene always contains considerable diopside, but only two cases are known in which the diopside and jadeite are present in about equal amount (one being the Tuxtla statuette), while the pyroxene in the Copan pebble is the only one known so far in which diopside dominates greatly over jadeite. This difference is so marked that it gives rise to the thought that, possibly, the Copan jade belongs to a petrographical series of jades which is distinct from the others, and thus possibly comes from a different locality.

BOTANY.—*Two new species of letterwood* (Piratinera). S. F. BLAKE, Bureau of Plant Industry.[1]

The letterwood, snakewood, bois des lettres, or letterhout[2] of commerce is the heartwood of the species of the Moraceous genus *Piratinera* Aubl., all of which are native in the Guianas, the Amazon region of Brazil, and Panama. Aublet, describing the original species, *Piratinera guianensis*, says[3] that it is called "bois des lettres" by the Creoles of French Guiana, and "boutous" by the Galibis, who used the inner wood in making bows and clubs. Canes and pestles were also made from it. A variety with white heartwood, called "bois des lettres blanc," and supposed by Aublet to be only a young state of the same species, was used by the negroes in the manufacture of walking sticks. For this purpose the straightest branches were selected and the bark removed. They were then stained a permanent black with a dye made by mixing soot with the sap of a species of *Inga* known as "bourgoni" (*Mimosa bourgoni* Aubl., now known as *Inga bourgoni* (Aubl.) DC.), and when polished had the appearance of ebony.

Letterwood has been an article of commerce from the earliest settlement of British Guiana. The timber was originally procured from fallen trunks from which the sapwood had long since rotted away. Although such material is still occasionally dug up from the forest floor, the prevailing practice is to fell the timber and split and hew

[1] Received September 26, 1922.

[2] It should be noted that the name "letterhout" is not restricted to species of *Piratinera*, but is used also, as proved by other material received from Professor Record, for *Helicostylis tomentosa* (Poepp. & Endl.) Rusby and a species of *Sahagunia* (?), and the same is true of many others of the vernacular names recorded in this paper.

[3] Pl. Guian. 2: 890. 1775.

off the sapwood in the forest, sending to market the heart portions which are 3 to 8 inches in diameter and 7 or 8 feet long. Its principal use in this country is for the manufacture of walking sticks and umbrella handles. Minor uses include drum sticks, butts of fishing rods, violin and archery bows, and miscellaneous fancy articles. It is also employed to a limited extent in cabinet work, but only in the form of sawn veneers. The native Indians have long used it for making their bows and various other articles requiring great strength and elasticity.[4]

The letterwood trees inhabit the lowlands and not infrequently attain a diameter of two and rarely of three feet. The trunks are long and slender, covered with a smooth bark rich in milky latex, and have a very thick layer of light-colored sapwood surrounding a small, often irregular core of red or reddish-brown heartwood that is as heavy as lignum-vitae. Commercial wood is spotted all over with peculiar black markings which bear some semblance to hieroglyphics and often give to the surface the appearance of snake skin. Not all of the heartwood is figured in this way, and the native cutters cannot tell until they have cut through the sapwood whether the heart will be speckled or only striped with black. It has been supposed that the speckled wood was indicative of a certain species, but studies of sections of tree trunks which accompanied the herbarium material described in this paper prove that this feature is not a specific character.

Prof. Samuel J. Record, of the School of Forestry of Yale University, who is making a thorough investigation of many tropical American woods, has recently sent me for study a considerable number of specimens of Moraceae which he secured from British and Dutch Guiana, including no less than 12 sheets of *Piratinera*, as well as some detached leaves representing other collections. Full credit for the collection of these important specimens should be given to Mr. J. W. Gonggrijp, Conservator of Forests of Surinam, Mr. L. S. Hohenkerk, Forest Officer of British Guiana, and Mr. C. W. Anderson, formerly Forest Officer, whose efforts have provided material for the settlement of one of the many problems connected with the identification of tropical American trees of commercial importance. As preliminary examination of this material showed that it represented three species with distinctive foliar characters, leaves of all three

[4] This paragraph and the following one have been contributed by Professor S. J. Record.

were sent to Dr. A. B. Rendle of the British Museum, who has kindly compared them with Aublet's type of *P. guianensis* and thus established the identity of that species.

It has been customary to refer the name *Piratinera* Aubl. (1775) to *Brosimum* Sw. (1788), and the latter name was made a *nomen conservandum* by the International Botanical Congress at Vienna in 1905. A few years ago, however, Mr. Henry Pittier[5] brought forward evidence to show that the genera were distinct, being separable by the number of pistillate flowers (1 in *Brosimum*, 2 or more in *Piratinera*), and the presence of a perianth in the staminate flowers of *Piratinera*, as well as by differences in the shape of the receptacle. The last feature seems to be of minor significance, but the floral characters brought forward by Pittier are sufficient to justify the separation of the two genera. Another point of interest in the separation of the two genera is brought out in Professor Record's study of the wood of various species. He finds that the heartwood of *Piratinera* is never white, while that of *Brosimum* is always white, except in *B. paraense*, a species of somewhat doubtful generic position.

Five species of *Piratinera* were listed by Pittier,—*P. guianensis* Aubl., *P. discolor* (Schott) Pittier, *P. rubescens* (Taub.) Pittier, *P. acutifolia* (Huber) Pittier, and *P. panamensis* Pittier,—of which only the last two have hitherto been represented in the National Herbarium. In the light of the material now at hand, the separation of the first two species seems to be unjustified. *Brosimum discolor* Schott, briefly described[6] in 1827, was fully described in 1853 by Miquel,[7] who had examined an authentic specimen. Miquel described the under surface of the leaves as glaucescent and subsericeous-pubescent with short, appressed hairs. This is the diagnostic feature of the species, well represented in Prof. Record's material, which has been identified by Dr. Rendle with the type of *P. guianensis* Aubl., and as no distinguishing characters are apparent in Miquel's long description, it is evident that *P. discolor* (Schott) Pittier should be referred to the synonymy of *P. guianensis* Aubl.

With this reduction, and the addition of the two new species represented in the material sent by Prof. Record, the known species of *Piratinera* are increased to 6. All except *P. rubescens* are now rep-

[5] Contr. U. S. Nat. Herb. 20: 96–100. 1918.

[6] In Spreng. Syst. Veg. 4: 403. 1827.

[7] In Mart. Fl. Bras. 4: 110. 1853.

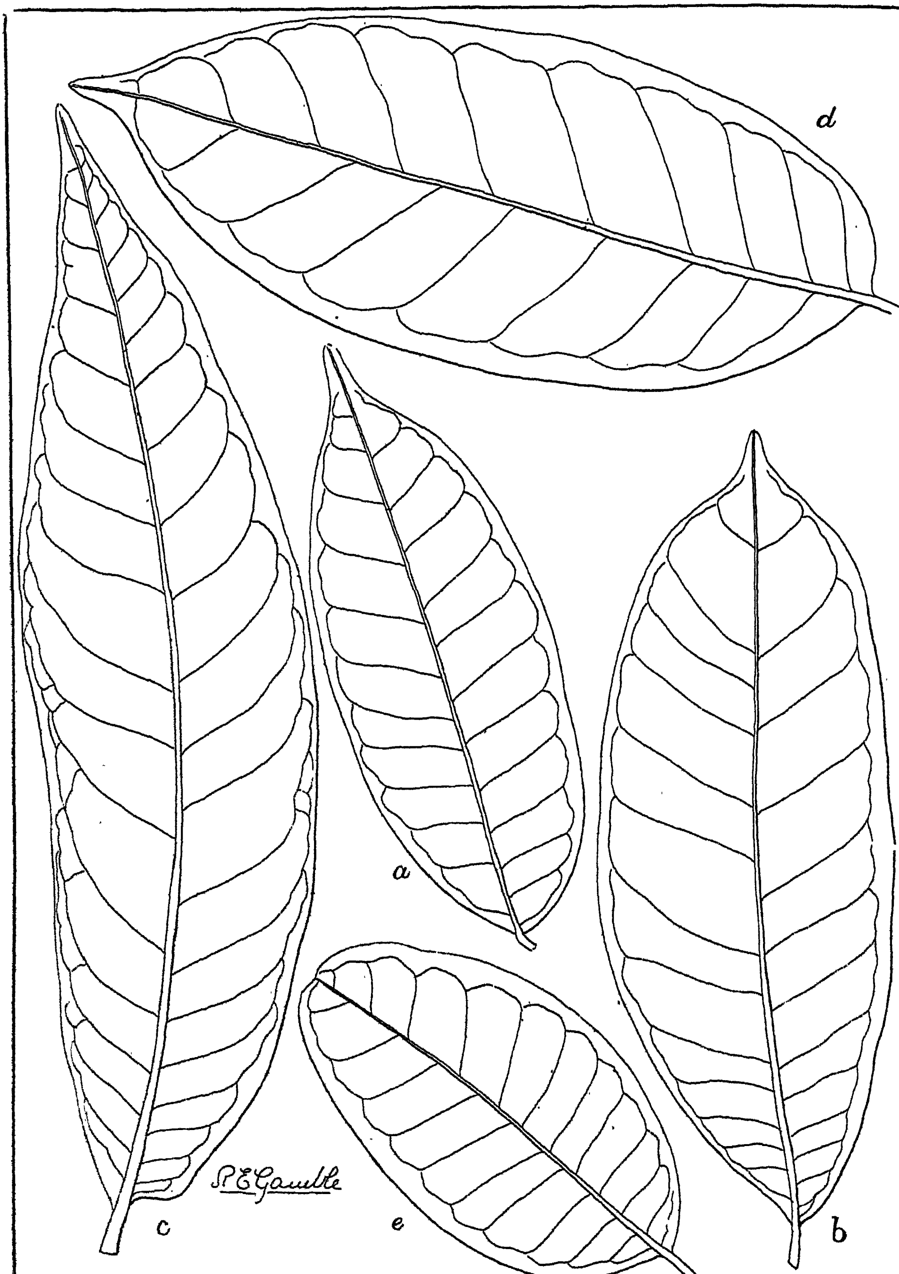

Fig. 1. Leaves of *Piratinera*, natural size.—*a*, *P. guianensis* Aubl. (*Anderson* 598A); *b*, *P. panamensis* Pittier (type collection); *c*, *P. acutifolia* (Huber) Pittier (*Ducke* 12155); *d*, *P. velutina* Blake (type); *e*, *P. scabridula* Blake (type).

resented in the National Herbarium. The following key based chiefly on the leaves will serve to separate the species.

Leaves finely appressed-puberulous beneath.
- Leaves rather densely appressed-puberulous beneath; peduncles solitary, erect.
  - Petioles 2 to 5 mm. long; peduncles (in flower and fruit) 3 to 8 mm. long; receptacle in flower 3.5 to 7 mm. wide. 1. *P. guianensis.*
  - Petioles 5 to 7 mm. long; peduncles (in flower and fruit) 10 to 15 mm. long; receptacle in flower 1 cm. wide or more. 2. *P. panamensis.*
- Leaves very sparsely appressed-puberulous beneath chiefly along the costa; peduncles usually paired, refracted. 3. *P. rubescens.*

Leaves densely puberulous to pilosulous beneath with spreading or incurved but not appressed hairs.
- Leaves gradually long-acuminate, puberulous beneath with incurved hairs; chief lateral veins 14 to 22 pairs. 4. *P. acutifolia.*
- Leaves emarginate or rounded to abruptly short-acuminate, hispidulous or pilosulous beneath with straight spreading hairs; chief lateral veins 8 to 12 pairs.
  - Leaf blades mostly 4.5 to 7.5 cm. long, 2 to 4 cm. wide, hispidulous along costa above, very densely scabridulous-hispidulous on surface beneath with minute hairs much shorter than the thickness of the leaf tissue. 5. *P. scabridula.*
  - Leaf blades mostly 7 to 12 cm. long, 3 to 5.5 cm. wide, glabrous above, rather densely velvety-pilosulous on surface beneath, the hairs about as long as the thickness of the leaf tissue. 6. *P. velutina.*

1. **Piratinera guianensis** Aubl. Pl. Guian. **2**: 888. *pl. 340.* 1775. PALE-LEAF LETTERWOOD. Fig. 1, *a.*

Brosimum discolor Schott in Spreng. Syst. Veg. 4^2: 403. 1827.
Brosimum guyanense Huber, Bol. Mus. Goeldi **5**: 337. 1909.
Piratinera discolor Pittier, Contr. U. S. Nat. Herb. **20**: 100. 1918.

TYPE LOCALITY: Caux, French Guiana.

ILLUSTRATIONS: Aubl. Pl. Guian. *pl. 340.* Miq. in Mart. Fl. Bras. 4^1: *pl. 33* (as *B. discolor*).

SPECIMENS EXAMINED:

BRITISH GUIANA: Komentyne (Komantin) Creek, Wiruni River, and Berbice River (near savanna of Karaka), February 18, 1910, *C. W. Anderson* 467/C. T. 45 (N, Yale).[8] Essequibo-Rupumuni region, *Anderson* 598A (N, Yale). On hills up to 15 or 20 meters above sea level, Kamuni Creek, Demerara River, *Anderson* 137 (Yale). Issororo Creek, Pomeroon River, June 8, 1909, *Anderson* 308 (Yale).

SURINAM: Zandery I., a station at Km. 45 of railway, November 25, 1915, *Forestry Service* (*Surinam*) 1371 (Yale). Moderzorg, Surinam River, August 8, 1921, *Forestry Service* 5429 (Yale). Sarwa Creek, Mapane, Commewyne River, November 22, 1921, *Forestry Service* 5497 (Yale, fragm. N). Berlyn, Km. 50 of railway, December 13, 1921, *Forestry Service* 5501 (Yale, fragm. N).

BRAZIL: Obidos, Amazonia, December 22, 1907, *Ducke* 9189 (N).

[8] In the citation of specimens, N = U. S. National Herbarium; Yale = herbarium of Yale University.

The vernacular names accompanying the British Guiana material are "letterwood" (no. 598A) and "tibikushi" (*i.e.*, bastard letterwood; nos. 137, 308, 467). No. 308, which consists only of comparatively large leaves (about 11 cm. long, 5.5 to 6 cm. wide) and of a wood specimen (the latter not examined by the writer), is labeled "not true tibikushi." Although considerably larger than those of the other specimens examined, these leaves agree in pubescence, and seem to be clearly referable to *P. guianensis*. No. 137 is said to grow to be a large tree on sandy soil, the bark emitting a sticky substance when cut, and the heartwood being red mottled with black.

The material from Surinam is labeled with the following names: "letterhout," "letterhout (gespikkeld)," "man letterhout" (Dutch); "manletri," "kappewerie letri" (Negro English); "moejé-paulettoe" (Saramacca Bush Negro); "koeréroe," "koléro," "koelero" (Arowak Indian); "paida," "toekoesipaida," "wékérépaida" (Carab Indian)."

In his list of the described species of *Brosimum*, Pittier[9] recognizes *B. guianense* Huber as a valid species distinct from *Piratinera guianensis* Aubl. This course is not in accordance with the rules of nomenclature, since Huber published the name, in the form *Brosimum guyanense*, without description, and cited *Piratinera guyanensis* Aubl. and *B. aubletii* Poepp. as synonyms. Three collections were listed, nos. 4871, 9189, and 9072. The two latter are in the National Herbarium, as mentioned by Mr. Pittier. Investigation of these, in the light of the information recently obtained as to the identity of Aublet's type, shows that no. 9189 is referable to *P. guianensis* Aubl. No. 9072, however, is referable to the new species described beyond as *Piratinera velutina*. In a later note by Huber,[10] cited by Pittier as the place of publication of *B. guianense*, where the wood is described (with the vernacular name given as "muirapinima"), reference is again made to *P. guianensis* Aubl.

2. **Piratinera panamensis** Pittier, Contr. U. S. Nat. Herb. **20:** 100. *pl. 7.* 1918. PANAMA LETTERWOOD. Fig. 1, *b*.

TYPE LOCALITY: Near Puerto Obaldía, Panama.

SPECIMENS EXAMINED:

PANAMA: Hills back of Puerto Obaldía, San Blas Coast, September 2, 1911, *Pittier* 4336 (type collection, N).

The vernacular name of this species is given as "guaímaro." Prof. Record, who has studied wood material collected by Mr. Pittier, informs me that the sapwood is white, and the heartwood dark red with black markings.

3. **Piratinera rubescens** (Taub.) Pittier, Contr. U. S. Nat. Herb. **20:** 100. 1918. REDLEAF LETTERWOOD.

Brosimum rubescens Taub. Bot. Jahrb. Engler **12:** Beibl. **27:** 4. 1890.

TYPE LOCALITY: Brazil. Type collected by Glaziou (no. 12169).

The vernacular name of this plant is given as "páo vermelho."

[9] Contr. U. S. Nat. Herb. **20:** 101. 1918.

[10] Bol. Mus. Goeldi **6:** 168. 1910.

4. **Piratinera acutifolia** (Huber) Pittier, Contr. U. S. Nat. Herb. **20:** 100. 1918. SHARPLEAF LETTERWOOD. Fig. 1, *c*.
Brosimum acutifolium Huber, Bol. Mus. Goeldi **6:** 66. 1910.

TYPE LOCALITY: Primeval woods along the railroad between Belem and Bragança, Pará, Brazil. Type collected by A. Goeldi (no. 8231).

SPECIMEN EXAMINED:
BRAZIL: Rio Branco de Obidos, Pará, 4.8.1912, *Ducke* 12155 (N).

This species is readily recognized by its long-acuminate leaves. The vernacular name is "mururé."

5. **Piratinera scabridula** Blake, sp. nov. ROUGHLEAF LETTERWOOD. Fig. 1, *e*.

Tree with sticky latex; young branches slender, brown or purplish brown, minutely and rather sparsely spreading-hispidulous, glabrescent, the older flaky-barked, becoming gray; buds ovoid, acute, about 2.5 mm. long, finely erect-hispidulous; internodes 2 to 20 mm. long; stipules not seen; petioles 2 to 5 mm. long, sulcate above, finely hispidulous with spreading or erectish hairs; leaf blades elliptic to oval or sometimes obovate-oval, (2.7) 4.5 to 7.5 cm. long, (1.3) 2 to 4 cm. wide, obtuse or obtusely short-pointed to rounded, often emarginate, at base cuneate or rounded-cuneate and unequal, entire, subcoriaceous, above usually light green, shining in age, glabrous except along the hispidulous costa, beneath pale, along costa and chief veins spreading-hispidulous, on surface scabridulous to the touch with very dense and very minute, conical, spreading, whitish hairs, featherveined, the chief veins 8 to 12 pairs, diverging at an angle of 60° to nearly 90°, united inside the margin, flattish or barely prominulous above, prominulous beneath, the costa prominulous above, prominent beneath, the secondaries prominulous-reticulate beneath; peduncles axillary, solitary, erectish, about 7 mm. long, minutely antrorse-hispidulous; young receptacle depressed-hemispheric, about 4 mm. thick, covered with orbicular, peltate, minutely puberulous and ciliolate bracts; ♀ flowers about 5; ♂ flowers numerous, 1-androus, the perianth monophyllous, apparently split on one side; fruit not seen.

Type in the U. S. National Herbarium, no. 1,120,360, collected below Manakobi, on the Corentyn River, British Guiana, December 13, 1909, by C. W. Anderson (no. 406/C8). Duplicate in the herbarium of Yale University.

ADDITIONAL SPECIMENS EXAMINED:
SURINAM: Casipora Creek, Surinam River, November 24, 1921, *Forestry Service* 5495 (Yale, fragm. N). Irakoeka Creek, Surinam River, January 11, 1922, *Forestry Service* 5499 (Yale), 5500 (Yale, fragm. N).

The vernacular name associated with the type is "letterwood." The Dutch names of the other specimens are given as follows: "manletterhout" (5495), "kapiteinhout" (5499), "roode letterhout" (5500). The Arowak Indian name of 5495 is "koelero boelekolle." The label of the type collection states that the flowers were greenish yellow with brown anthers. Unfortunately only a single receptacle has been available for examination, and that is too young and in too poor condition to afford much information, beyond establishing the fact that the plant is certainly a *Piratinera*.

The hairs of the under leaf surface in this species are so small that under a 12x lens they appear merely as densely crowded papillae. Viewed on a cross section of the leaf under a 49x binocular, they are seen to be conical hairs, standing off stiffly at a right angle from the leaf surface, and about one-half to one-fifth as long as the thickness of the leaf.

6. **Piratinera velutina** Blake, sp. nov. VELVETLEAF LETTERWOOD. Fig. 1, *d*.

Young branchlets brown, finely, densely, and rather softly spreading-puberulous, the older glabrate, gray-barked; internodes mostly 1 to 2.5 cm. long; stipules lance-subulate, 4.5 mm. long, appressed-puberulous on both sides, deciduous; petioles 3 to 5 mm. long, scarcely sulcate above, puberulous like the branchlets; leaf blades oblong to oblong-oval, rarely slightly obovate-oval, (5) 7 to 12 cm. long, 3 to 5.5 cm. wide, abruptly short-pointed with obtuse apex, at base very unequal, broadly rounded on one side, obliquely rounded on the other, entire, subcoriaceous, above deep green, shining, glabrous, beneath paler (brownish or griseous-green when dry), on the chief veins hispidulous-pilosulous with rather soft spreading or antrorse hairs, on surface very densely papillose and rather densely and softly velvety-pilosulous with spreading hairs, featherveined, the chief lateral veins 8 to 11 pairs, diverging at an angle of 60° to 80°, united inside the margin, with the secondaries flattish or delicately prominulous-reticulate above, prominulous-reticulate beneath, the costa prominent beneath; peduncles (very young) solitary, axillary, erect, puberulous, 5 mm. long or less; young receptacles depressed-subglobose, about 4.5 mm. thick, densely covered with orbicular, peltate, puberulous and ciliolate bracts; ♀ flowers 2 or 3; ♂ flowers numerous, 1-androus, the perianth monophyllous, split on one side; fruit not seen.

Type in the U. S. National Herbarium, no. 1,120,361, collected at Sectie O, a forest station at Km. 65 of railway, Surinam, February 15, 1916, by the Forestry Service of Surinam (no. 1647). Duplicate in herbarium of Yale University.

ADDITIONAL SPECIMENS EXAMINED:

SURINAM: Sectie O, November 3, 1915, *Forestry Service* 1158 (Yale), November 22, 1915, *Forestry Service* 1378 (Yale). Irakoeka Creek, Surinam River, January 11, 1922, *Forestry Service* 5498 (Yale).

BRAZIL: Alluvial forest, Rio Mapuera, Amazonia, December 8, 1907, *Ducke* 9072 (N).

The hairs on the under leaf surface of this species are much longer than those of *P. scabridula*, being readily distinguishable with a 12x lens, and about equaling the thickness of the leaf tissue when seen under the binocular.

The species bears the following names: "letterhout," "roode letterhout" (Dutch); "letri," "basra letri" (Negro English); "poevinga," "paulétoe" (Saramacca Bush Negro); "sokoné-biberoe," "belekoro," "koereroe" (Arowak Indian); "paida," "wékéré paida," "tianalin wéivé," "tokoro apolli merie" (Carab Indian).

DOUBTFUL SPECIES

Brosimum aubletii Poepp. & Endl. Nov. Gen. & Sp. 2: 34. *pl. 148, f. a-d.* 1838.

This species, from the banks of the Rio Huallaga near Yurimaguas, Peru, was stated by its authors to be without doubt identical with *Piratinera guianensis* Aubl. Pittier,[11] however, considers it "probable that it belongs neither to Brosimum nor to Piratinera, but perhaps to Helicostylis." The description and figures of the receptacle and floral parts, however, particularly of the peltate bracteoles, seem to me to indicate that the plant is a *Piratinera*, and that the staminate flowers were overlooked. The difference in range makes it improbable that the plant is identical with Aublet's species. Until more information is secured, it is impossible to dispose of the name definitely.

BOTANY.—Diospyros conzattii, *a new species of persimmon from Mexico.*

PAUL C. STANDLEY, U. S. National Museum.[1]

The National Museum has received recently from Prof. C. Conzatti of Oaxaca, Mexico, specimens of a native persimmon which can not be referred satisfactorily to any of the ten species previously listed from the country. The Mexican species of the genus are endemic, with two exceptions—*Diospyros ebenaster* Retz., an East Indian species with large fruit (4 to 7 cm. in diameter or larger), which is widely cultivated, being known commonly as "zapote prieto;" and *D. texana* Scheele, the "chapote" or "chapote prieto," which extends into western Texas. All the Mexican persimmons have edible fruit, whose pulp is usually black at maturity. The species here described is an interesting addition to the known trees of Mexico, especially since the collector has furnished such complete information concerning it.

Diospyros conzattii Standl., sp. nov.

Tree, 10 meters high, the branchlets minutely and sparsely fulvous-puberulent; petioles 4 to 6 mm. long, minutely puberulent or glabrous; leaf blades ovate-oblong or lance-oblong, 5 to 9.5 cm. long, 2.5 to 3.5 cm. wide, acuminate, acute or subobtuse at base, subcoriaceous, glabrous, somewhat lustrous above, the costa depressed, the lateral nerves nearly obsolete, the costa prominent beneath, the lateral nerves also prominent, slender, irregular, 5 or 6 on each side; fruits borne on short stout pedicels; calyx 5-parted, the lobes narrowly lance-oblong or linear-lanceolate, 15 to 18 mm. long, long-attenuate, glabrous or sparsely strigillose outside near the base; fruit depressed-globose, about 4 cm. broad and 2 cm. high, glabrous, green, the pulp black; seeds 5 to 10, strongly compressed, about 13 mm. long and 10 mm. broad, brown, finely rugulose.

Type in the U. S. National Herbarium, no. 1,014,759, collected in the Cafetal San Rafael, Cerro Espino, Distrito de Pochutla, Oaxaca, Mexico, April 24, 1917, by C. Conzatti (no. 3167).

[11] Contr. U. S. Nat. Herb. 20: 98. 1918.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received September 26, 1922.

Diospyros conzattii is not closely related to any of the species previously reported from Mexico, with the possible exception of *D. blepharophylla* Standl. (*D. ciliata* A. DC.), a little-known plant, the type of which is said to have come from southern Mexico. That is described as having ovate-elliptic ciliate leaves, on longer petioles.

From a manuscript work upon the edible fruits of Mexico, Professor Conzatti has furnished the following notes concerning the new species here described:

"On the twenty-fourth of April, 1917, while making an excursion in the company of Señor E. Makrinius, manager of the Cafetal Concordia and its subsidiaries, District of Pochutla, Oaxaca, on the so-called Cerro Espino, upon which lies the Cafetal San Rafael, I had the good fortune to find among other things a medium-sized (10 meters) tree, known there as *zapote negro montés*. At that time of the year the tree bore leaves and ripe fruits. Sampling the fruits, with some suspicion at first, I found them quite to my taste and ate as many as I could. But I prefer to quote what I have already published in the *Boletín de la Dirección de Estudios Biológicos*:[2]

" 'The *zapote negro montés* is especially interesting because of its edible fruit, of exquisite flavor. With the exception of the *chicozapote*, I know of no other fruit which compares in quality with the *zapote negro*, and all the persons who have tried it are agreed in considering it superior to that. The fruits, which are perfectly round, and green outside, are much smaller than those of the common *zapote negro* (*Diospyros ebenaster*), being only 4 cm. in diameter and 2 cm. or slightly more in height, since they are somewhat depressed.

" 'It seems to me that propagation of the tree should be relatively simple, taking into account the elevation (1,000 meters) at which it grows and the fact that it is native.' "

BOTANY.—*A new Salvinia from Trinidad.*[1] William R. Maxon, National Museum.

In Christensen's Index Filicum 13 species of water fernworts of the genus *Salvinia* are recognized, these mainly inhabitants of tropical regions. Of the few American species, *S. sprucei*, known from a single collection in the Amazon region, has been unique in having ascending, somewhat cup-shaped leaves, in distinction from the plane blades of the small floating leaves of other species. Recently a new species closely allied to *S. sprucei* has been collected in Trinidad. This is described below.

[2] II. 3: 316. 1918.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received September 6, 1922.

Salvinia cyathiformis Maxon, sp. nov

Plants small, 1 to 1.5 cm. long, 1 cm. broad, or less; stem filiform (about 0.3 mm. thick), bearing a few deciduous short few-celled hairs. Submerged radiciform leaves imperfect, conceptacles wanting. Floating leaves few, 2 or 3 pairs (the nodes 3 or 4 mm. apart), petiolulate (about 0.5 mm.), olivaceous above, darker beneath, 5 to 6 mm. long, subflabelliform, cyathiform, truncate-subcordate at base, broadly rounded in the apical portion, not emarginate, conduplicate in drying, the folded blade 4 to 5 mm. broad, appearing cuneiform, with an acutish or narrowly roundish-cuneate base; midvein slight, subflexuous, hardly thicker than the lateral veins; main lateral veins 6 or 7 pairs, connected in oblong areoles oblique from the midvein, each areole subtending two narrowly oblong or linear areoles toward the margins, the excurrent veinlets mostly free, occasionally producing a minute areole; papillae numerous on the upper side in a wide marginal zone 1.5 to 2 mm. broad, linear, about 1 mm. long, borne mostly upon the ultimate cross-veins and between the excurrent veinlets, greenish-hyaline, cleft at the tip.

Type in the U. S. National Herbarium, no. 1,058,520, collected from a pond at Cedros, Trinidad, December 20, 1914, by W. E. Broadway; received from the New York Botanical Garden.

In habit and in form and venation of the floating leaves *S. cyathiformis* resembles *S. sprucei* Kuhn, of Brazil, founded on *Spruce* 1636. That species as described and figured in the Flora Brasiliensis, and as known to the writer from a portion of the type collection courteously lent from Kew, has the leaves much less deeply cup-shaped, broadly cuneate, and devoid of papillae upon the upper surface, except for a few at the extreme margin that are so minute as to have escaped Kuhn's attention. The leaf substance of *S. sprucei* is much thinner than that of *S. cyathiformis*, and the venation is in consequence much more sharply defined.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

162ND MEETING

The 162nd meeting of the Academy, the 24th annual meeting, was held at the Administration Building of the Carnegie Institution of Washington, on Tuesday, January 10, 1922. The meeting was called to order by Vice-President HUMPHREYS. Dr. ALFRED H. BROOKS, retiring President of the Academy, delivered an address, entitled, *The scientist in the Federal service.* This has since been published in the JOURNAL of the Academy (**12**: 73–115. Feb. 19, 1922).

Following the address the annual business meeting was held. The minutes of the 21st annual meeting were read and approved. The Corresponding Secretary, ROBERT B. SOSMAN, reported briefly on the activities of the Academy during the year. On January 1, 1922, the membership consisted of 6 honorary members, 3 patrons, and 534 members, the total being 543, of whom 325 reside in or near the District of Columbia. Nine resignations were accepted during the year, and the Academy lost by death the following

members: EDWARD CHESTER BARNARD, FREDERIC PERKINS DEWEY, LOUIS ALBERT FISCHER, FRANZ A. R. JUNG, EDWARD BENNETT ROSA, SAMUEL STOCKTON VOORHEES. Other matters dealt with included the movement initiated by the Botanical Society of sending scientific literature to the scientists of Russia, the wider distribution of the JOURNAL to Continental European countries, and the compilation by the committee of the Academy of a list of 100 popular books in science. The list, prepared at the suggestion of Dr. GEORGE F. BOWERMAN, Librarian of the Public Library of the District of Columbia, has been widely circulated and commented upon. The activities of the Academy in advocating the establishment of a national arboretum and botanical garden on Mount Hamilton were also discussed.

The Recording Secretary, WILLIAM R. MAXON, reported also on the nine public meetings held during 1921, in addition to the annual meeting, at which illustrated lectures were delivered. Several of these were held jointly with one or more of the societies affiliated with the Academy. The titles and dates, and the place of publication of the lectures, were stated.

The report of the Treasurer, R. L. FARIS, showed total receipts of $6,382.79 and total disbursements of $6,196.89; the cash balance on hand December 31, 1921, was $1,978.52. Investments of the Academy have a total par value of $15,036.37. The cost of printing the JOURNAL in 1921 was $3,701.23, as against $2,550.00 for 1919 and $2,873.74 for 1920.

The report of the Auditing Committee, consisting of W. R. GREGG, S. H. AYRES, and E. G. FISCHER, was read and the reports of the Treasurer and the Auditing Committee were accepted.

The report of the Editors of the JOURNAL was read by ROBERT B. SOSMAN, the senior Editor. Various economies, including change in make-up and in size of page, had made possible the publication of 537 pages in Volume 11, equivalent to about 620 pages of former volumes. Original articles, 53 in number, took up 61 per cent of the pagination, Proceedings of the Academy and the Affiliated Societies 18 per cent, Abstracts 11 per cent, and News, Notes and Index the remaining 10 per cent.

The Committee of Tellers, consisting of H. W. BEARCE, ROBERT H. LOMBARD, and ROBERT B. SOSMAN, reported that the following officers had been elected for 1922: *President*, W. J. HUMPHREYS; *Corresponding Secretary*, F. B. SILSBEE; *Recording Secretary*, WILLIAM R. MAXON; *Treasurer*, R. L. FARIS; *Non-resident Vice-Presidents*, G. E. HALE, D. C. MILLER; *Managers Class of 1925*, L. J. BRIGGS, ROBERT B. SOSMAN.

The following vice-presidents, nominated by the affiliated societies, were then elected: *Archaeological Society*, AUSTIN H. CLARK; *Biological Society*, VERNON BAILEY; *Botanical Society*, CHARLES E. CHAMBLISS; *Chemical Society*, R. C. WELLS; *Institute of Electrical Engineers*, R. P. PARROTT; *Society of Engineers*, J. S. CONWAY; *Entomological Society*, S. A. ROHWER; *Society of Foresters*, RAPHAEL ZON; *National Geographic Society*, FREDERICK V. COVILLE; *Geological Society*, G. W. STOSE; *Historical Society*, ALLEN C. CLARK; *Medical Society*, A. W. BOSWELL; *Philosophical Society*, E. C. CRITTENDEN.

163D MEETING

The 163d meeting was held jointly with the Philosophical Society of Washington in the Assembly Hall of the Cosmos Club, the evening of Saturday, January 28, 1922. Dr. L. T. TROLAND, Professor of Psychology at Harvard University, delivered an address on *Psycho-physics as the key to metaphysics*.

This has been published in the JOURNAL of the Academy (12: 141–162. March 19, 1922).

164TH MEETING

The 164th meeting of the Academy was held jointly with the Geological Society of Washington in the Assembly Hall of the Cosmos Club, the evening of Thursday, February 2, 1922. Prof. H. A. BROUWER of the Geological Institute, University of Delft, Holland, delivered an illustrated address, entitled *The major tectonic features of the Dutch East Indies.* This has been published in the JOURNAL (12: 172–185. April 4, 1922).

165TH MEETING

The 165th meeting of the Academy was held jointly with the Anthropological Society of Washington in the Assembly Hall of the Cosmos Club, the evening of Thursday, February 16, 1922. Dr. H. U. SVERDRUP, of Amundsen's Arctic Expedition, delivered an address, entitled, *Customs of the Chukchi natives of northeastern Siberia.* A full abstract of this lecture has been published in the JOURNAL (12: 208–212. April 19, 1922).

WILLIAM R. MAXON, *Recording Secretary.*

PHILOSOPHICAL SOCIETY

865TH MEETING

The 865th meeting was held in the Cosmos Club auditorium April 8, 1922, with President CRITTENDEN in the chair, and 28 persons present. The President announced that a custom formerly prevailing—that of affording opportunity for the presentation of informal communications—would be a regular feature of programs in the future.

The following papers were presented:

F. H. SMYTH: *Experimentation at high pressures and temperatures, with special reference to the fusion of calcium carbonate* (illustrated).

The essential apparatus necessary for work at high pressures and temperatures are (1) a strong-walled gas-proof container or bomb, and (2) an electric furnace within the bomb with which temperatures up to 1500 degrees may be obtained. Electrical leads for the furnace and for the thermo-elements used in measuring furnace temperatures, may be brought out through small holes in the bomb wall, insulated and made gas-tight by soapstone plugs rammed in under pressure around the wires.

For pressures up to 1000 atm. a bomb of nickel steel of 10 cm. internal diameter, and 20 cm. depth, with a wall 7 cm. thick has been found satisfactory. The bomb wall is made with two shells, between which are grooves through which cooling water may be circulated. A small platinum wound resistance furnace of 14 mm. internal diameter is used as a heating element. Owing to the great heat losses due to convection in a gas atmosphere at high pressure, the furnace tube must be well baffled with small discs of refractory material, and the platinum crucible containing the heated charge must be in practically solid contact with the inside furnace wall.

The system studied to date is the two component system CaO-$CaCO_3$.

The best previous work on this system has been done by Boeke (N. Jb. Min. 1912, 1, 91–121) under conditions which permitted pressures up to 300 atm. Boeke reports a reversible change from one form of solid $CaCO_3$ to another at 970 deg. The eutectic between CaO and $CaCO_3$ is given as 1218 deg., and the melting point of pure $CaCO_3$ as 1289 deg. at 110 atm.

The results of the present investigation show that there is no change in solid $CaCO_3$ below the eutectic point. The eutectic lies between 1230 and 1240 deg., the corresponding gas pressures being 34 to 39 atm. The melting point of nearly pure $CaCO_3$ is 1335 deg., at a pressure of 1050 atm. Even under these conditions the fused carbonate contains a fraction of a per cent of lime. To get rid of the last traces of lime would probably require much higher pressures, but the melting point of the carbonate probably would not be greatly raised.

E. D. WILLIAMSON: *The prediction of solubility relations under high pressure from compressibility measurements* (illustrated). Discussed by Mr. HAWKESWORTH.

It is somewhat difficult to make direct solubility measurements under high pressure and it is therefore important to observe that such solubility relations can be accurately and unequivocally determined by indirect methods. The following data must be first obtained: (*a*) a set of equilibrium measurements covering the derived concentration at atmospheric pressure—say, vapor pressure or electro-motive force determinations; (*b*) accurate density determinations at atmospheric pressure; (*c*) compressibility measurements on both solutions and pure substances. The lack of trustworthy compressibility results for solutions has so far made calculations worthless, but this gap is now being bridged.

G. W. MOREY: *The production of pressure in magmas by crystallization* (illustrated). Discussed by Messrs. HUMPHREYS and WHITE. It has been published in full in the JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES, **12**: 219–230, 1922.

At the conclusion of the regular program informal communications were presented by L. H. ADAMS on *The stability of graphite and diamond*, and by W. P. WHITE on *The existence of amorphous material in metals*.

866TH MEETING

The 866th meeting was held in the Cosmos Club auditorium Saturday, May 6, 1922, with President CRITTENDEN in the chair, and 36 persons present. Program:

E. H. BOWIE: *The formation and movement of West Indian hurricanes*. Discussed by Messrs. L. H. ADAMS, HAWKESWORTH, HEYL, KADEL and PAWLING.

The formation and the manner of progression of the cyclones of all latitudes and especially those of the tropics have been perhaps more extensively referred to in the literature of meteorology than any other phenomena of the air. The old hypothesis accounted for their formation by the "clashing" of two or more major air currents, such as those that surge back and forth between the tropics and far northern latitudes. Ferrel took exception to this hypothesis and wrote extensively and rather convincingly on the part that local superheating of the lower air strata had to do with the formation of cyclones. The basis of Ferrel's hypothesis had back of it local heating and the deflective influence of the earth's rotation which gave rise to the counterclockwise circulation of the winds around a central region of warm or relatively warm air. Now, the hypothesis of local thermal convection as applied to the formation of cyclones rests exclusively on the supposition that cyclones are warm up to a considerable altitude. Free-air observations wherever made fail to prove this to be a fact, for in Europe the cyclone is found to be cold or relatively cold, while in the United States, at least east of

the 100th Meridian, the free-air observations disclose the fact that the eastern half of the cyclone is warm and the west half cold. No doubt if similar free-air observations were made in the far northwest in the winter months it would be found that, in cyclones in British Columbia, Alberta, Washington, Oregon and Montana, the western half of the cyclone is warm and the eastern half cold, for certainly the surface distribution of temperature implies just this temperature distribution in the free-air in that region. The inference is that the distribution of temperature in the cyclone is but a question of whence came the air that passes into and out of the cyclone, and that the temperature distribution therein is purely incidental and not fundamental to the origin of the cyclone itself. The other important hypothesis assigned the formation of the cyclone to the more general movements in the air and asks one to look beyond the immediate place of the origin of the cyclone for its cause. The hypothesis is referred to as the "counter-current theory" and its most ardent advocate in recent years has been Bigelow. The more recent presentation by Bjerknes seems but a modified and differently presented account of the part counter-currents have in the formation of cyclones. It is assumed that these counter-currents on passing one another will cause a diminution of the air pressure above the intervening region, a welling up of the surface air strata, and thus bring about instability which will result in the formation of cyclones. It is also assumed that similar air currents passing one another in the reverse direction will bank together and produce ridges of high pressure or anticyclonic areas. The existence of such counter-currents in the tropical and extra-tropical regions is well supported by observations. The deflective force of the earth's rotation is an important adjunct to the counter-current hypothesis and it follows that counter-currents passing one another on the right will maintain a belt of low barometeric pressure and those passing one another on the left will maintain a ridge of high barometric pressure between them. The energy arising from the condensation of water vapor after the cyclone has formed no doubt contributes to its length of life. Attempt is made to account for the progression of cyclones as moving along the region bounded by counter-currents, such as the "Polar Front" named by Bjerknes, although above the cyclone proper the air stream over and on both sides of the cyclone may and no doubt frequently does flow in the same general direction.

E. B. CALVERT: *Radiating the weather* (illustrated). Discussed by C. A. BRIGGS.

Radio is an indispensable factor in the work of the Weather Bureau and since 1902, when the first storm warning was sent out by this means, it has become of constantly increasing importance in the collection of weather reports and in the dissemination of forecasts and warnings. The Weather Bureau early recognized the potentiality of radio telegraphy as an aid to its projects and was a pioneer among Government agencies in engaging in experiments and investigations looking toward developing and improving it. These experiments were begun in 1900 and continued for several years. During this period a transmitter and receiver were developed, the principles of which were in general use for a long time.

Weather observations are collected daily from 210 places in the United States; 30 in Canada; 36 in the West Indies, Cuba and South American countries; 12 in the Pacific and the Far East, including Honolulu, Guam, Midway Island, Philippines, China and Japan; 22 in Europe; 17 in Mexico

and 9 in Alaska, from which a current daily meteorological chart of the northern hemisphere is prepared. These reports are obtained by telegraph, cable, telephone and radio, but the latter is used wholly or in part in connection with the collection and transmission of the observations from Europe, West Indies and South America, the Far East and Alaska. Radio is also used in providing the meteorological services of Europe, the Philippines and Japan with reports from the United States, Canada and Alaska in exchange.

The vessel weather service is an important and exceedingly valuable feature of the work of the Weather Bureau. Radio communications are utilized almost exclusively in connection therewith. Observations are taken regularly on vessels plying the south Atlantic and Pacific oceans, the Caribbean Sea and the Gulf of Mexico. These observations are radioed twice daily to the forecast centers at Washington and San Francisco and are charted in conjunction with land reports. Cyclone and anti-cyclone centers are located over these water areas, their intensity, direction of movement and rate of progress are determined, and forecasts and warnings are broadcast for the benefit of ships of all nations. During the year 1921 about 10,000 observations were received by radio from ships at sea. The value of this service, especially during the hurricane season, in the saving of ships, lives and cargoes is enormous. The dissemination of the forecasts and warnings to ships is accomplished entirely by U. S. Naval radio stations. Comprehensive weather bulletins containing observations from land and sea areas, synopses of barometer distributions over land and sea, wind and weather forecasts for designated ocean zones and storm and hurricane warnings are broadcast twice daily from 5 high-power stations; and local bulletins and forecasts from 31 naval radio stations on the Atlantic, Gulf and Pacific coasts, and on the Great Lakes. This service for the benefit of navigation is the most complete, extensive and effective in the world.

It has not been possible to extend the benefits of the weather forecasts, cold wave, heavy snow, frost and other warnings to the agricultural interests of the country as effectively as to commercial and navigation interests, because of the inaccessibility of a large portion of farmers to the telegraph and telephone lines, and to newspapers by which they are distributed for the most part. The marvellous advance made in radio telephony offers a solution of this difficult and important problem. Farmers in increasing numbers are supplying themselves with receiving sets. The Weather Bureau has taken advantage of the opportunity and a system of broadcasting weather reports and warnings has been inaugurated in the different states. This system now embraces 80 stations in 34 states.

P. R. HEYL: *On a superior limit of n in Fermat's equation.* Discussed by Messrs. HEAL and HUMPHREYS.

If in Fermat's Equation $x^n + y^n = z^n$ we assign any arbitrary value to z we can find a critical value of n above which no integral solution of the equation is possible. This value of n is a slowly increasing function of z; hence by its means no general proof of Fermat's Last Theorem can be arrived at.

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PHYSICS.—*Temperature changes accompanying isentropic, isenergic, and isenkaumic expansion.*[1] LEASON H. ADAMS, Geophysical Laboratory, Carnegie Institution of Washington.

The pressure on a fluid may be changed from its initial value to some final value in several well-recognized ways. The temperature changes accompanying the release of pressure depend on the method by which the pressure is released, and may be calculated from the conventional equations of thermodynamics. It is the object of this communication to note, largely because of the connection with geophysical problems, the changes in temperature of typical fluids when pressure is released according to three principal methods.

These methods are as follows:

(A) *Reversible release of pressure. Isentropic expansion.*—This, the most familiar of the three kinds of expansion, takes place when a fluid (*i.e.*, a gas or a liquid) is expanded, for example in a cylinder with movable piston, without exchange of heat with the surroundings under such conditions that frictional effects are (sensibly) absent and slowly enough so that equilibrium is maintained, *i. e.*, that the external force acting on the piston is (sensibly) equal to the opposing force exerted by the fluid.

Under such conditions the entropy (S) of the fluid remains constant, the process is called *isentropic*, and the relation between temperature and pressure is given by the equatoin:

$$-\left(\frac{\partial T}{\partial p}\right)_s = -\frac{\alpha T}{c_p} \qquad (1)$$

in which T is the absolute thermodynamic temperature, c_p is the specific heat at constant pressure, α is the coefficient of expansion $\left(\frac{\partial v}{\partial T}\right)_p$, v being the volume of unit mass. The first member of

[1] Received October 13, 1922.

the equation is written $-\dfrac{\partial T}{\partial p}$ for convenience in representing the rise in temperature due to *decrease* of pressure.

(B) *Explosive release of pressure. Isenergic expansion.*—When pressure on a given amount of material is released in such a way that no heat is added to or taken away from the material and no work is done on or by the surroundings, the intrinsic energy (E) of the material remains constant, and the expansion may be termed *isenergic*. This type of expansion may be realized by allowing a gas to expand from one part of a container to another (evacuated) part, or—of more practical interest—by the sudden release of pressure on a liquid contained under high pressure in a bomb, *e. g.*, by a breaking of the walls or by a blowing off of the lid.

The relation between temperature and pressure in isenergic expansion is:

$$-\left(\frac{\partial T}{\partial p}\right)_E = \frac{\beta p - \alpha T}{c_p - \alpha p} \tag{2}$$

β being the compressibility, namely, $-\left(\dfrac{\partial v}{\partial p}\right)_T$

(C) *Porous plug release of pressure. Isenkaumic expansion.*—The third variety of expansion occurs when a fluid—as before, insulated thermally from the surroundings—reduces its pressure by streaming through a porous plug or through a throttle of some sort. In this case a certain thermodynamic quantity, represented by the letter H and commonly called heat content, remains constant. The expression, heat content, is sometimes confused with heat capacity and, moreover, the two-word name does not lend itself well to the formation of derivatives. Thus, "isoheatcontentic" would be an awkward term. For these reasons a single-word equivalent of heat content would be desirable, and the word *enkaumy*[2] is here proposed.

In the process just considered the enkaumy remains constant, and for this *isenkaumic* expansion the relation between temperature and pressure is:

$$-\left(\frac{\partial T}{\partial p}\right)_H = \frac{v - \alpha T}{c_p} \tag{3}$$

[2] Greek, καυμα from καιειν to burn. Cf. obsolete English word, *cauma*, heat. For the suggestion of this root I wish to thank my colleague, Dr. Henry S. Washington.

It is of interest to note that $-\Delta H$, the difference in enkaumy of two states, is the exact equivalent of the heat of combustion, or the heat of reaction, at constant pressure.

The equations given for the three types of adiabatic expansion apply strictly only when the pressure on the substance is purely hydrostatic, *i. e.*, equal in all directions. This limits the rigorous application of such formulas, particularly (2) and (3), to liquids and gases; but if the pressure on a solid be many times the strength of the material, the pressure may be nearly equal in all directions, and the equations may then be used for calculating the piezo-thermal effects in solids. The error involved will naturally be smaller, the larger the pressure. For example, when a metal is extruded through a die by a pressure of many thousands of atmospheres, the rise in temperature can be estimated from equation (3) and the known properties of the metal.

The temperature effects for the three kinds of expansion and for a number of typical substances are shown in the following table.

NUMERICAL VALUE OF TEMPERATURE RISE FOR THE THREE KINDS OF EXPANSION. $-\partial T/\partial p$ IS THE RISE, IN DEGREE CENTIGRADE PER MEGABAR FALL IN PRESSURE

Material	Temp. Deg. C.	Pressure megabars	$\partial T/\partial p$ At. const. S (Isentropic)	At. const. E (Isenergic)	At. const. H (Isenkaumic)
Nitrogen	0	1	−83.4	−0.38	−0.26
Hydrogen	0	1	−79.3	−0.02	+0.03
Water	20	1	−0.0013	−0.0013	+0.023
Water	20	4000	−0.0028	−0.0010	+0.021
Kerosene	20	1	−0.017	−0.017	+0.043
Lead	25	4000	−0.0020	−0.0013	+0.068

In making calculations with equations (1), (2) and (3) it is convenient to take v in cubic centimeters per gram, p in megabars (1 megabar = 0.9869 atmosphere at latitude 40°), and c_p in deci-joules per gram per degree (1 calorie = 41.84 deci-joules). An alternative way is to take p in kilograms per square centimeter, and c_p in kilogram-centimeters per gram per degree.

The values of $\left(\frac{\partial T}{\partial p}\right)_H$ for nitrogen and hydrogen in the above table were not calculated from equation (3), but are the results of direct measurements of this, the Joule-Thomson effect. Likewise it was more convenient to calculate $\left(\frac{\partial T}{\partial p}\right)_E$ for these gases from the relation:

$$-\left(\frac{\partial T}{\partial p}\right)_E = -\frac{\mu\, c_p + a}{C_v}$$

which holds with sufficient accuracy for gases. In this equation μ

is written for $\left(\frac{\partial T}{\partial p}\right)_H$ and a for $\left(\frac{\partial(pv)}{\partial p}\right)_T$. Values of both μ and a for the more common gases are to be found in the literature.

The kerosene referred to is the ordinary commercial product having a density of about 0.8.

Probably the temperature always falls in isenergic expansion—at least over the range of temperatures and pressures which have hitherto been investigated. This is equivalent to the statement that the internal energy of a substance steadily decreases as the pressure is increased.[3] Isentropic expansion causes a fall in temperature, except in those rare cases where the expansion coefficient is negative, *e. g.*, water below 4° C. For isenkaumic expansion, however, there is no such regularity. At temperatures sufficiently high the temperature of a fluid rises during isenkaumic expansion; at intermediate temperatures it falls; while at still lower temperatures it again rises, except at pressures above a certain limit, under which conditions the change is always a rise.[4] At moderate pressures there are thus two inversion points where $\left(\frac{\partial T}{\partial p}\right)_H$ changes sign. One is somewhere near the ordinary boiling-point, while the other is at a temperature several times the critical temperature.

Since the βp and αp terms in equation (2) are small for liquids except at high pressures $\left(\frac{\partial T}{\partial p}\right)_S$ and $\left(\frac{\partial T}{\partial p}\right)_E$ for ordinary liquids are practically identical at low or moderate pressures. It is hardly necessary to point out that for an ideal gas $\alpha T = \beta p = v$, and hence for an ideal gas the right-hand members of equations (2) and (3) reduce to zero. For ordinary solids and liquids v is much greater than αT; therefore $-\left(\frac{\partial T}{\partial p}\right)_H$ is practically equal to $\frac{v}{c_p}$. Thus, the heating effect when such materials are expanded isenkaumically is nearly equal to the thermal equivalent of the work done (vdp) in forcing the material through the porous plug or throttle—more approximately the total heating effect is the algebraic sum of this thermal equivalent of the net work done on the substance, and of the cooling effect accompanying isentropic expansion, the latter being comparatively small for all solids and liquids. For these materials,

[3] Cf. P. W. Bridgman. Proc. Am. Acad. Sci. **48**: 348. 1912.

[4] Cf. W. McC. Lewis. System of Physical Chemistry, Vol. II, p. 71. London, 1920.

therefore, we may, if we like, regard the rise in temperature during extrusion as being (nearly) that due to the conversion of the work expended on them into heat, this conversion being effected by friction along the walls or by internal friction (viscosity); but for gases, of course, this is not even approximately true.

It is of interest in this connection to note the behavior of antimony when extruded through a small opening. According to Bridgman the extrusion at certain pressures proceeds slowly and regularly, but if the pressure is raised to a certain critical value, the antimony comes out with almost explosive violence and in the form of a long, continuous wire. Now the temperature rise for isenkaumic expansion of antimony is about the same as for lead, namely about 70° per 1000 megabars. Since the pressure was 10,000 megabars or more, the question may well be raised as to whether the antimony, in spite of heat losses, may not have been raised to its melting point at ordinary pressure, namely, 630° C.

PHYSICS.—*Some observations on the transformation of thermal radiant energy into electric current in molybdenite.*[1] W. W. COBLENTZ, Bureau of Standards.

As announced in the Bureau of Standards Tech. News Bulletin, No. 61 of May 11, 1922, during the past year the writer has been searching for a possible relation between (1) an e.m.f. which is observed in isolated spots in certain samples of molybdenite when exposed to thermal radiation but without an impressed e.m.f., and (2) the photoelectrical reaction (which is usually considered a change in resistance) exhibited in these same spots when subjected to an impressed e.m.f. and exposed to thermal radiation.

The materials examined are narrow strips of molybdenite 1 to 6 cm. in length, soldered to copper wires which are connected with a Thomson galvanometer.

Touching the copper-molybdenite junctures with a thin hot wire produces the well known thermal e.m.f. of a heterogeneous circuit. Touching the intervening parts of the crystal with the hot wire produces no e.m.fs.

On the other hand, focusing the short wave-length radiations from a Nernst glower or tungsten-ribbon lamp upon different parts of the

[1] Received September 16, 1922

crystal, remote from the electrodes, produces, in some samples, local e.m.fs. which differ in magnitude and in polarity.

Exposing a spot, exhibiting a high local e.m.f., to an equal energy spectrum, an electric current is generated which is a function of the intensity and the wave-length of the light stimulus, and of the thickness of the crystal. The maximum effect was produced by wave-lengths extending from 0.6 to 0.8 micron, and no e.m.f. was found for wave-lengths greater than 1 micron.

The spots exhibiting local e.m.fs., caused by thermal radiation do not seem to coincide always with the spots exhibiting the photoelectrical reactions (change in resistance) when there is an impressed e.m.f.; though further investigation may show that this is owing to the fact that the thermal e.m.f. effect is found to be extremely small in comparison with photoelectrical reaction.

The polarity of this newly observed thermal e.m.f. may be photonegative or photopositive, depending upon the wave-length of the thermal radiation stimulus just as was previously observed for the photoelectrical reaction (resistance change) when there is an external e.m.f. It is therefore an interesting question whether the so-called photoelectrical reactions in solids, when subjected to an impressed e.m.f., are an amplification of the e.m.fs. produced by the thermal radiation but without an impressed e.m.f.

PHYSICS.—*A device for recording electric contact using an electron tube generator and a radio-frequency spark.*[1] CHARLES T. ZAHN, Princeton University. (Communicated by S. W. STRATTON.)

It is sometimes desirable to have a convenient means of recording an electric contact of relatively short duration, of the order of one thousandth of a second. For a particular use it was found that various devices which have been used heretofore were either not satisfactory or not convenient. It was suggested that the use of the three-electrode electron tube generator might be successful. The following is a description of some experiments performed at the radio laboratory of the Bureau of Standards with this end in view, and is given here simply to illustrate a new experimental method.

The three-electrode electron tube generator was used as a source of radio-frequency alternating current to produce a radio-frequency

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce. Received September 19, 1922.

spark, by means of the high voltage induced in a coil whose natural frequency is the same as that of the applied field. (This radio frequency was about 300,000 cycles per second.) The *duration* of this spark was controlled by an electric contact within the generator circuit, and registered by letting the spark puncture a moving piece of carbon paper. It was a matter of experiment to see how nearly the spark, with the particular arrangement used, followed the electric contact made and broken in the generator circuit.

The exact arrangement of apparatus which was first used is shown in Fig. 1. It consists of a simple electron tube generator and a rotating chopper K used to make and to break the contact at the filament terminal of the tube and thus to start and to stop the generation of radio-frequency current, respectively. The coil L_3 is a large coil of

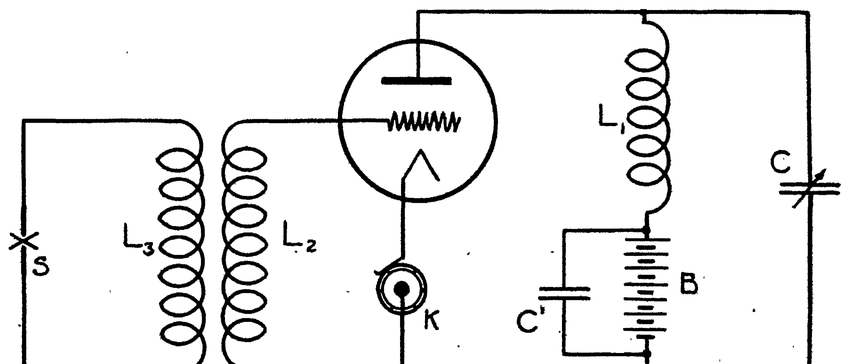

Fig. 1. Generating circuit, commutation at filament terminal.

the type known as "stagger wound" or sometimes as "spider web," and has a natural frequency of such a value that the generator can be tuned to it by means of the condenser C. By means of coupling the coil L_3 with coils L_1 and L_2, which are coupled to each other, and tuning, a radio-frequency voltage is induced in the coil L_3 sufficient to maintain a series of sparks between the coil terminals when they are brought close together as shown in Fig. 1. The duration of this series of sparks is registered in the following manner. The chopper K is divided into alternate equal segments of insulating and conducting material so that the spark exists for equal time intervals separated by time intervals equal to those of the spark duration. A piece of carbon paper in the form of a cylinder is made to rotate about its axis in synchronism with the chopper by having it wrapped around a brass drum which is mechanically coupled to the shaft which rotates the

chopper. One terminal of the coil L_3 is connected to this brass drum and the other terminal in the form of a needle point is fastened within a millimeter's distance from the carbon paper. During the time when the chopper makes contact a spark passes between the needle point and the brass drum through the carbon paper, and while the contact is interrupted no spark passes. Thus the carbon paper is punctured at equal intervals around the cylinder.

The arrangement of apparatus for another method of controlling the radio-frequency current is shown in Fig. 2. Here a resistance R of about 10 ohms, sufficient to prevent the generation of radio-frequency current, is inserted in the oscillating circuit of the tube. The chopper is connected across this resistance. When this resistance is short circuited by the chopper, radio-frequency current is generated.

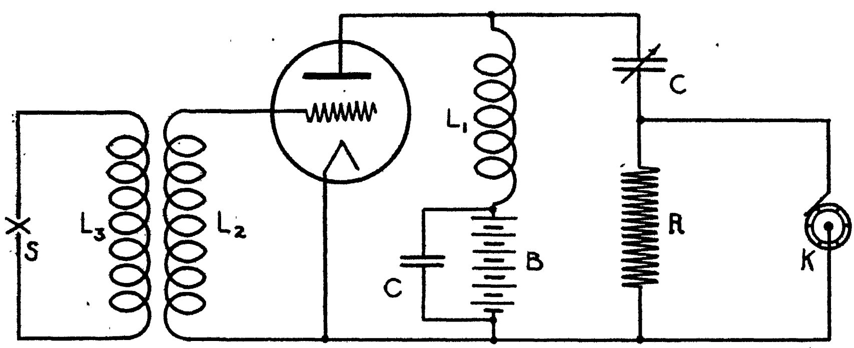

Fig. 2. Generating circuit, commutation by inserting resistance.

This latter method is better for cases where sparking at the contact is objectionable, for in the former method the chopper interrupts the plate current.

The following experimental details may be of interest. Several types of coil for L_3 and several types of electron tubes were tried. The stagger-wound coil gave the best results as regards power considerations. At first a General Electric Type P pliotron tube rated at 250 watts was used at rated plate voltages. This gave much more power than was necessary, so several other combinations were tried, to see whether enough power could be generated using 220 volts on the plate of the tube. With this latter plate voltage neither a General Electric Type P 250-watt tube, nor two General Electric Type U 50-watt tubes, nor four Western Electric Type E 5-watt tubes gave sufficient power: therefore, it was decided to use a single Type U tube with 500 volts on the plate.

The following is an application of this electron tube recorder. In the Automotive Power Plant Section of the Bureau of Standards a method has been devised to record automatically the pressure-volume curve for a gas engine cycle.[2] A mechanical arrangement was worked out which for any given pressure makes an electric contact continuously during the time of the cycle when the pressure in the engine cylinder is greater than or equal to this given pressure. Thus the pressure in the engine cylinder is equal to this given pressure at times corresponding to the makes and the breaks of electric contact, and these times correspond to points on the curve whose ordinates are equal to the given pressure. It was attempted to register this time of contact by low-frequency sparks. A drum covered with carbon paper was to be rotated in synchronism with the engine, and for any given pressure the time of sparking would be registered on the paper. For the different pressures parallel lines would be registered, all of which together would give the pressure diagram in the form of an area of sparks. The

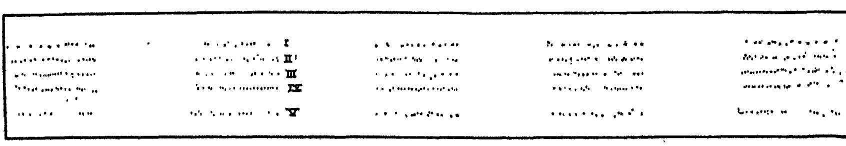

Fig. 3. Carbon paper record of spark passing when chopper contact is closed.

difficulties found in trying to use low-frequency methods should be obviated by applying the device described in this paper.

The time of duration of the radio-frequency spark in the experiments described in the beginning of this paper is actually registered as a series of dots about a millimeter apart and the equality of time interval of contact and open circuit is registered on the carbon paper to an accuracy corresponding approximately to the distance between the dots just mentioned. It is believed that if the length of spark gap is reduced, the accuracy of the production of equal intervals can be considerably increased. The fact that a series of dots is obtained instead of a continuous cut in the paper is probably due to differences in conductivity of the paper at different points or to an effect on the tube generator due to the passing of the spark from the coil L_3. The frequency of these dots is about one fiftieth that of the radio-frequency.

[2] H. C. Dickinson and F. B. Newell, "A High-Speed Engine Pressure Indicator of the Balanced Diaphragm Type," Report No. 107 of the National Advisory Committee for Aeronautics, Washington, 1921. Government Printing Office.

The accompanying Fig. 3 is a reproduction of five series of these dots, each series corresponding to a different position of the needle. The first four series were taken with different speeds of rotation of the drum the maximum linear speed of the carbon paper being about 500 cm. per second; the last series was registered with the direction of rotation reversed. This diagram shows that there could not have been a time lag in starting or stopping the generator corresponding to more than 2 millimeters on the carbon paper, *i.e.*, there could not have been a lag of more than 1/2500 second.

The writer is indebted to Mr. F. B. Newell for the loan of special apparatus used in performing these experiments and to Mr. L. E. Whittemore for valuable suggestions in the work.

ZOOLOGY.—*A new species of* Nygolaimus, *an outstanding genus of the Dorylaimidae.*[1] N. A. COBB, United States Department of Agriculture.

The *Dorylaimidae* constitute one of the largest families of nemas, its type genus *Dorylaimus* alone doubtless containing many hundreds of species. For a time it appeared that the individuals comprising the family constituted an unusually homogenous group. Later discoveries are dispelling this idea to a considerable extent. The form described herein belongs to one of the more outstanding genera, *Nygolaimus*. It is too early to speculate very profitably as to the relationships of the *Dorylaimidae* to other nemic families, but the structure of *Nygolaimus* stimulates hypotheses.

Recently the *Dorylaimidae* have come into consideration as an economic factor in the soil; additional information with regard to their structure and habits is therefore much to be desired, and this is one of the main reasons for the publication of the following note.

Nygolaimus denticulatus n. sp. $\frac{1.8 \quad 5.4 \quad 22. \qquad \text{Y.} \qquad 98.8}{1.1 \quad 1.3 \quad 1.6 \qquad 1.6 \qquad 1.4}$ 4.3 mm. The thick layers of the transparent, colorless, naked cuticle, measuring five microns through near the head and fifteen microns on the tail, are traversed by very fine transverse striae, difficult of resolution, which are not altered on the lateral fields. It is barely possible with the highest powers to resolve these striae into rows of excessively faint dots. The striae are near the surface of the cuticle, probably in the thin outer layer, which measures about three-fourths of a micron in thickness. The contour of the body is plain. There are no dermal

[1] Received October 19, 1922.

appendages. On each lateral field, extending from near the head to the tail, there is a *double series of sublateral pores* not forming exact lines but arranged slightly irregularly, the distance between them averaging somewhat less than the diameter of the body. This distance, however, varies somewhat and is perhaps a little greater anteriorly than posteriorly, so that there are toward one hundred fifty pores on each lateral field. Each of these organs at its surface presents a slight but relatively broad depression in the cuticle. From the center of this depression there extends inward at right angles to the surface of the body a narrow tube, three-fourths of a micron in diameter, which extends to the lateral chord, where it rather suddenly expands and connects with a broadly *saccate unicellular gland* located in the tissue of the chord. These glands and ducts are a prominent feature of the anatomy of the living nema and strike the observer at first glance, especially if the nema be viewed dorso-ventrally. The neck, which is cylindroid posteriorly and more or less conoid anteriorly, becomes convex-conoid at the continuous, subtruncate to truncate, head. The mouth opening is central, depressed, and relatively conspicuous. It is surrounded by six confluent, subspherical, well-developed lips, each supplied with two minute papillae which do not interfere with the rounded contour of the lip; one of them is outward pointing and the other also barely outward pointing. This latter, the anterior one, is located near the border of the lip region; the posterior one, somewhat farther back and on the outer surface of the lip region. It seems possible that the lips, or some of them, present additional very faint papillae. The somewhat hexagonal lip region, which is nine microns high and

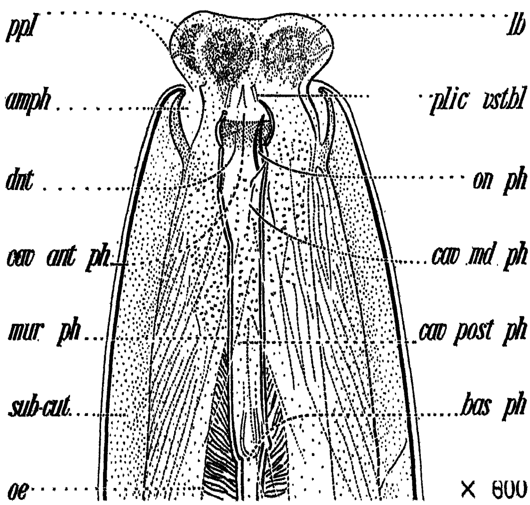

Fig. 1. Somewhat oblique ventral view of the head end of *Nygolaimus denticulatus n.sp.* *ppl*, anterior and posterior labial papillae; *amph*, amphid; *dnt*, denticles lining the wall of the pharynx; *cav ant ph*, *cav md ph*, *cav post ph*, anterior, median and posterior segments of the pharynx; *mur ph*, wall of the pharynx; *sub-cut*, subcuticle; *oe*, oesophagus; *lb*, lip region; *on ph*, onchium; *bas ph*, base of the pharynx; *plic vstb*, folds in the vestibule.

eighteen microns wide, is distinctly set off by constriction; and especially laterally, on account of the *large and conspicuous amphids*, located just at the base of the lip region. The pharynx is entered through a vestibule, more or less hexagonal when closed, about nine microns long and at its narrowest part, when the lips are at rest, normally not over one micron wide. The pharynx, like other parts of the anatomy, is distinctly dorylaimoid, but the very small *left ventrally submedian tooth-like onchium*, only six microns long and one and one-half microns wide at the base, instead of being tubular, as in *Dorylaimus*, is closed. *The food does not pass through it*, but to one side. Speaking broadly the pharynx is of double structure,—the anterior portion being somewhat napiform or fusiform, and the posterior more or less tubular or prismoid. To go into particulars, the pharynx may be said to be divided into four parts, arranged tandem, reached through a narrow vestibule from the somewhat flaring mouth opening. Part one, the shortest part, about five microns long, extends from the vestibule to the region opposite the apex of the solid onchium, and might be regarded as a portion of the vestibule. This portion of the pharynx is characterized by the presence in its wall of several short longitudinal ribs or refractive folds, no doubt six in number. The second portion of the pharynx, a little longer than the preceding and with it forming a broadly fusiform cavity, is the portion of the pharynx containing the onchium, and is lined throughout the greater portion of its length with a *multitude of excessively fine denticles*, apparently similar to those found in the pharynx of some mononchs, and, as there, slightly larger and more regular anteriorly. The third portion, eleven microns long, is the anterior third of the tubular part of the pharynx, while the fourth and longest portion, twenty microns long, is the posterior two-thirds of that tube. Thus the entire pharynx is *nearly sixty microns long*. The distinction between parts three and four is not very marked; it manifests itself in the varying refractivity of the lining of the two parts, and also in the tendency of the posterior part to be more prismoid or cylindroid, while the anterior third tapers slightly from front to back. The thickness of the various parts of the highly refractive walls of the pharynx is somewhat variable,—from a

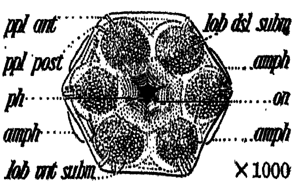

Fig. 2. Front view of the lip region of *Nygolaimus denticulatus* n.sp. *ppl ant*, *ppl post*, anterior and posterior labial papillae; *ph*, pharynx; *amph*, amphid; *lob vnt subm*, *lob dsl subm*, ventrally and dorsally submedian lobes of the lip region; *on*, onchium.

half to one micron thick. The width of the main, that is, posterior, portion of the cavity of the pharynx is about four microns. The *slender slightly arcuate onchium* is one-third as long as the lip region is wide and when at rest reaches one-third the distance from its base to the anterior border of the head. It is a left ventrally submedian organ, and may almost be said to be set *in a pharyngeal niche of its own.* Not only is it slightly arcuate but the tendency is for its apex to be swung outward a little when at rest. It tapers from its base to its acute anterior extremity and at its widest part is about one-fourth as wide as the adjacent cuticle is thick. That portion of the compound pharnyx behind the base of the onchium is about one and one-half times as long as the part in front of it, vestibule included. It is the *posterior two-thirds of the fusiform widest portion of the pharynx which is lined with the above-mentioned denticles.* The large amphids, like the onchium, are very much like those of *N. pachydermatus*, and are very conspicuous, and externally somewhat *escutcheon shaped;* they have their front borders removed from the anterior extremity of the nema a distance about one-third as great as the corresponding diameter of the head. They are about three-fifths as wide as the corresponding part of the head and nearly as long as wide. There are no eyespots. The oesophagus, which is dorylaimoid, enlarges somewhat gradually near the middle; the two parts of the oesophagus are not very clearly set off from each other. Behind the pharynx the oesophagus is about one-third, at the nerve ring about one-fourth, and finally about one-half as wide as the corresponding portion of the neck. The lining of the oesophagus is a very distinct feature throughout its length; anteriorly it is tubular and highly refractive and about one-fourth as wide as the oesophagus; posteriorly it is more distinctly triquetrous and somewhat wider—again about one-fourth as wide as the corresponding portion of the oesophagus. The musculature of the oesophagus is rather coarse and colorless. It is not yet known positively whether there are any glands in the tissue of the oesophagus—but it is almost certain that they are present. The conoid cardia is about one-third as wide as the base of the neck. There are no valves in the oesophagus. The rather opaque thick-walled intestine, which presents a faint, very slightly zigzag lumen, becomes at once one-half as wide as the body, and is separated from the oesophagus by a collum about one-third as wide as the base of the neck. It is composed of cells of such a size that about six are presented in each cross section. There is a *distinct pre-rectum* about five times as long as

the corresponding width of the body. It is set off from the intestine not only by being slightly less in diameter but by being more nearly colorless; the intestine itself is yellowish on account of the presence in its cells of certain exceedingly fine yellowish granules. The rectum is readily seen to lead inward and forward from the depressed anus a distance about equal to the anal body diameter. The anus is a transverse slit two-fifths as wide as the corresponding portion of the body. The fine granules of rather variable size which are numerous in the cells of the intestine are *some of them yellowish in color* and taken altogether so arranged as to give rise to a faint tessellated effect. The largest of them are not much over one micron across. The tail is nearly hemispherical. There is no spinneret and there are no caudal setae. Extending backward and outward from the conoid protoplasmic "core" of the tail there are ten to twelve innervations, which are much less clearly visible than are the two tubes leading outward and backward from the two lateral glands located in the tail,—the final members of the lateral series already mentioned. Similar innervations occur toward the head end of the nema and probably to a less extent throughout the body. The cuticle on the tail is very much thicker than elsewhere (15 microns) and is characterized by the presence in it of longitudinal markings which indicate that it is probably finely laminated. The lateral chords, about one-sixth as wide as the body, are deep, about as thick as the body wall—and are coarsely granular. Their cells are made up largely of subspherical granules closely packed together and of such a size that the largest, some four microns across, are about one-twentieth as wide as the body. Among these granules are scattered others, ellipsoidal, measuring up to one micron, and characterized by blackening in Flemming's solution. The nerve ring, which surrounds the oesophagus somewhat squarely, is accompanied by numerous rather obscure nerve cells. Nothing is known concerning the renette. Nothing is known concerning the sexual organs.

Habitat: Found in soil collected by Prof. J. R. Christie at Falls Church, Va., August 29, 1922. Only one young specimen seen. Examined and measured alive in water, and afterwards fixed in Flemming's solution and examined in glycerine.

Nygolaimus is manifestly related to *Dorylaimus*. It undoubtedly belongs to the *Dorylaimidae*, although it may possibly be regarded as a "transition form." Some features of the pharynx remind one strongly of *Mononchus*. The new onchia are sometimes prepared some dis-

tance behind the pharynx, as in *Dorylaimus*. *N. denticulatus* appears to be closely related to *N. pachydermatus*, in which quite possibly dermal pores may have been overlooked.

The mouth structures of *Nygolaimi* appear to harmonize with the supposition that the lip region can be expanded and the lips everted. Otherwise it is rather difficult to understand how the onchium can be efficiently used. The denticles are in relatively about the same position as in *Mononchus*, subgenus *Mylonchulus*, but not in two distinct patches. It seems quite apparent that the vestibule, when closed, is disposed in folds which would admit of its opening out in accordance with the above supposition. The Nygolaims are carnivorous.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

156TH MEETING

The 156th meeting of the Botanical Society of Washington was held at the Cosmos Club, on January 3, 1922, with about 75 members and guests present, and President SAFFORD in the chair. Messrs. ERNST F. ARTSCHWAGER, ARTHUR C. DILLMAN, Dr. CHAS. DRECHSLER, Dr. ARTHUR S. RHOADS, ERNST S. SCHULTZ, VICTOR F. TAPKE, and W. H. TISDALE, all of the Bureau of Plant Industry, were elected members of the Society.

Brief notes and reviews of literature.—P. L. RICKER stated that the letter from Dr. HENRY MUHLENBERG, written in 1809, and containing a list of the flora of the District of Columbia had already been purchased by Mr. W. L. MCATEE. W. W. DIEHL spoke of the desirability of making of a list of the fungus flora of the District. Mr. RICKER added that a tentative list of the mycological flora of the District was now being prepared.

Regular program:

L. R. JONES: *Predisposition and resistance to disease in plants.*

Plant pathology is now in a transition period. For some time we have been talking of disease resistance without getting much nearer to the fundamentals underlying this resistance. Such questions must be answered as the particular relation of a particular parasite to a plant, the relation of environment to resistance, etc.

Much of the work of pathologists has been and still is the search for resistant strains or varieties of plants to certain diseases. This is a work which the geneticist and horticulturist can do far better than the plant pathologist. The latter's particular field is not to search for resistant strains, much as this is worth while, but to search for causes of resistance. This involves a study of cell pathology, the study of a single parasite and of single cells of the host plant. Only a beginning has been made on this fundamental work.

Symposium on plant breeding for disease resistance.

W. J. HUMPHREY, *Cereal crops.*—In the cereal crops some diseases were transmitted with the seed as in the case of the smuts. Some measure of success had been achieved with seed treatment, both with the use of chemicals and the hot water treatment. It is not enough to develop a disease-resistant grain, for some of the grains developed by cross breeding, while highly resistant to certain diseases, lacked in milling qualities or in yield. The aim of the plant pathologist and the plant breeder was to secure not only disease-resistant varieties of grain, but to secure grain of good yield and quality.

W. W. GILBERT, *Cotton, truck and forage plants.*—A double gain was obtained by securing disease resistant plants; a gain in the product itself and a gain in the greater utilization of the land. There are certain requisites for selection and hybridization, to get disease resistant varieties or species. 1. The land must be naturally or artificially infected. 2. Work must be carried on in an environment suitable for the disease. 3. The use of a large number of varieties or strains.

The question arises, Is disease resistance in plants permanent? The failure of the cotton farmer to continue selection in the case of wilt-resistant cotton, shows how this resistance to disease becomes lessened. Resistance to disease is specific. One variety or one plant may be resistant to one disease, but that does not signify a resistance to all other diseases.

MERTON B. WAITE, *Fruits.*—Much of the early work in breeding for disease resistance in plants was carried on by natural selection, the survival of the fittest, as well as consciously by orchardists. The gardener and orchardist have done as much as the plant breeder or plant pathologist along this line. A number of projects were being worked in the Bureau of Plant Industry, including Dr. Swingle's work of breeding for resistance to citrus canker. The breeding of resistant stocks was emphasized as being important.

P. L. RICKER, *Grasses.*—New grasses are being introduced into this country from various foreign countries. Some of these are found to be subject to various diseases in their native country, as well as in this country. One of the biggest problems is in connection with lawn grasses on golf links, which suffered from so-called sun scald, which was found to be a Rhizoctonia. Strains of grasses which were resistant to this disease in one year, were propagated vegetatively and were fairly immune for a couple of years, but in the third year were wiped out completely.

ROY G. PIERCE, *Recording Secretary.*

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MATHEMATICS.—*Values of sine θ and cosine θ to 33 places of decimals for various values of θ expressed in sexagesimal seconds.*[1] C. E. VAN ORSTRAND and MARVIN A. SHOULTES, Geological Survey.

One hundred preliminary values of both the sine and cosine were computed several years ago in collaboration with the late Dr. George F. Becker with the object in view of constructing complete tables of the natural values of the six trigonometric functions. In the meantime Professor J. Peters[2] published 870 values of the sine, and cosine, to 21 places of decimals, the interval of the argument for the first 10′ being 1″, and for the remainder of the semiquadrant, 10′. During the interval 1911–18, the elaborate tables to 15 places of decimals by Professor H. Andoyer[3] of the University of Paris were published. An unnumbered volume contains values of the logarithmic sines, cosines, tangents, and cotangents; and in volumes 1 to 3, respectively, are tabulated natural sines and cosines; tangents and cotangents; secants and cosecants. The interval of the argument in all of the tables is 10″. Volume 1 contains also natural values of each of the six trigonometric functions to 20 decimals for arguments expressed in hundredths of a quadrant. Andoyer's tables are the first to replace the great work of George Joachim Rheticus consisting of the Opus Palatinum, published in 1596 and containing 10 place values at intervals of 10″ for all of the trigonometric functions; and the Thesaurus Mathematicus which was published in 1613 and contains 15 place values of the natural sine at intervals of 10″ throughout the entire quadrant, and in addition, values of the same function to the same

[1] Published with the permission of the Director of the U. S. Geological Survey. Received June 30, 1922.

[2] PETERS, J. *Einundzwanzigstellige Werte der Funktionen Sinus und Cosinus zur genauen Berechnung von zwanzigstelligen Werten sämtlicher trigonometrischen Funktionen eines beliebigen Arguments sowie ihrer Logarithmen.* Abh. Königl. Preuss. Akad. Wiss. 1–54. 1911.

[3] ANDOYER, H. *Nouvelles tables trigonométriques fondamentales (logarithmes)*; same (*valeurs naturelles*).

number of decimals at intervals of 1″ for the first and last degree of the quadrant. Detailed information in regard to these and other tables is given by Andoyer, Glaisher,[4] and Horsburgh.[5]

The fundamental values required for the evaluation of the functions tabulated in the accompanying tables were obtained by the substitution of

$$x = 0.04848\ 13681\ 10953\ 59935\ 89914\ 10235\ 79479\ 760$$

in the series, thus obtaining values of $\sin\theta$ and $\cos\theta$ for 10,000″. The values for 1″, 10″, 100″, and 1000″ were then easily obtained from the preceding computations of $x^n/n!$ by making the appropriate displacements in the decimal point. With these values as a basis, new values were computed at equal intervals of the argument by means of repeated applications of the formulae for $\sin(x + y)$ and $\cos(x + y)$. Both functions were computed at the same time with a "Millionaire" computing machine. Each computation was verified independently. We have for example,

$$\sin(x \pm y) = \sin x \cos y \pm \cos x \sin y.$$

By addition of the last to the preceding term of this equation we obtain $\sin(x + y)$, a new quantity; similarly by subtraction, we obtain $\sin(x - y)$, a quantity previously computed. Apart from checks provided by each subsequent interpolation at equal intervals, comparisons were of course made at 15°, 30°, and 45° by means of the known values[6] of $\sqrt{2}$, $\sqrt{3}$, and $\sqrt{6}$. All of the computations were carried to 35 places of decimals.

Andoyer's table 1, volume 1, contains expansions in series for each of the six trigonometric functions, the variable angle being written, $x\,\pi/2$. The coefficients in these series are tabulated to 24 places of decimals. In table 3, volume 1, each function is tabulated to 17 places of decimals at intervals of 9′. Tables I and II may be useful in connection with these tables and the tables of Peters previously mentioned. A careful comparison of our values with the corresponding values given by Peters and Andoyer revealed no errors in any of the computations. The plus signs following Andoyer's tabulations were also found to be given correctly.

[4] See article, *Table, mathematical*, in *Encyclopedia Britannica*.

[5] HORSBURGH, E. M. *Modern instruments and methods of calculation, a handbook of the Napier tercentenary exhibition.*

[6] BOORMAN, J. M. *Square-root notes.* Math. Mag. 1: 207–8. 1882–4. MARTIN, A. *Extraction of the square roots by series.* Math. Mag. 1: 164–5. 1882–4.

TABLE I.—VALUES OF SINE θ

θ″	Sine θ						
1	0.00000	48481	36811	07636	78200	79090	941
2	.00000	96962	73622	03878	29452	38417	064
3	.00001	45444	10432	77329	26805	60891	947
4	.00001	93925	47243	16594	43311	34785	949
5	0.00002	42406	84053	10278	52020	56404	615
6	.00002	90888	20862	46986	25984	32767	058
7	.00003	39369	57671	15322	38253	84284	359
8	.00003	87850	94479	03891	61880	47437	958
9	.00004	36332	31286	01298	69915	77458	047
10	0.00004	84813	68091	96148	35411	51001	965
11	.00005	33295	04896	77045	31419	68832	588
12	.00005	81776	41700	32594	30992	58496	724
13	.00006	30257	78502	51400	07182	77003	508
14	.00006	78739	15303	22067	33043	13502	792
15	0.00007	27220	52102	33200	81626	91963	541
16	.00007	75701	88899	73405	25987	73852	222
17	.00008	24183	25695	31285	39179	60811	203
18	.00008	72664	62488	95445	94256	97337	142
19	.00009	21145	99280	54491	64274	73459	381
20	0.00009	69627	36069	97027	22288	27418	340
21	.00010	18108	72857	11657	41353	48343	911
22	.00010	66590	09641	86986	94526	78933	846
23	.00011	15071	46424	11620	54865	18132	160
24	.00011	63552	83203	74162	95426	23807	513
25	0.00012	12034	19980	63218	89268	15431	611
26	.00012	60515	56754	67393	09449	76757	598
27	.00013	08996	93525	75290	29030	58498	445
28	.00013	57478	30293	75515	21070	81005	348
29	.00014	05959	67058	56672	58631	36946	118
30	0.00014	54441	03820	07367	14773	93983	577
31	.00015	02922	40578	16203	62560	97453	948
32	.00015	51403	77332	71786	75055	73045	251
33	.00015	99885	14083	62721	25322	29475	695
34	.00016	48366	50830	77611	86425	61172	069
35	0.00016	96847	87574	05063	31431	50948	141
36	.00017	45329	24313	33680	33406	72683	045
37	.00017	93810	61048	52067	65418	93999	675
38	.00018	42291	97779	48830	00536	78943	085
39	.00018	90773	34506	12572	11829	90658	871
40	0.00019	39254	71228	31898	72368	94071	575
41	.00019	87736	07945	95414	55225	58563	071
42	.00020	36217	44658	91724	33472	60650	959
43	.00020	84698	81367	09432	80183	86666	963
44	.00021	33180	18070	37144	68434	35435	318
45	0.00021	81661	54768	63464	71300	20951	167
46	.00022	30142	91461	76997	61858	75058	953
47	.00022	78624	28149	66348	13188	50130	812
48	.00023	27105	64832	20120	98369	21744	966
49	.00023	75587	01509	26920	90481	91364	117
50	0.00024	24068	38180	75352	62608	89013	840

TABLE 1.—VALUES OF SINE θ (*Continued*)

θ″	Sine θ						
50	0.00024	24068	38180	75352	62608	89013	840
51	.00024	72549	74846	54020	87833	75960	974
52	.00025	21031	11506	51530	39241	47392	018
53	.00025	69512	48160	56485	89918	35091	522
54	.00026	17993	84808	57492	12952	10120	483
55	0.00026	66475	21450	43153	81431	85494	734
56	.00027	14956	58086	02075	68448	18863	341
57	.00027	63437	94715	22862	47093	15186	994
58	.00028	11919	31337	94118	90460	29416	399
59	.00028	60400	67954	04449	71644	69170	673
60	0.00029	08882	04563	42459	63742	97415	740
61	.00029	57363	41165	96753	39853	35142	716
62	.00030	05844	77761	55935	73075	64046	310
63	.00030	54326	14350	08611	36511	29203	213
64	.00031	02807	50931	43385	03263	41750	491
65	0.00031	51288	87505	48861	46436	81563	982
66	.00031	99770	24072	13645	39137	99936	684
67	.00032	48251	60631	26341	54475	22257	150
68	.00032	96732	97182	75554	65558	50687	882
69	.00033	45214	33726	49889	45499	66843	724
70	0.00033	93695	70262	37950	67412	34470	254
71	.00034	42177	06790	28343	04412	02122	178
72	.00034	90658	43310	09671	29616	05841	721
73	.00035	39139	79821	70540	16143	71837	023
74	.00035	87621	16324	99554	37116	19160	531
75	0.00036	36102	52819	85318	65656	62387	390
76	.00036	84583	89306	16437	74890	14293	839
77	.00037	33065	25783	81516	37943	88535	603
78	.00037	81546	62252	69159	27947	02326	285
79	.00038	30027	98712	67971	18030	79115	761
80	0.00038	78509	35163	66556	81328	51268	570
81	.00039	26990	71605	53520	90975	62742	310
82	.00039	75472	08038	17468	20109	71766	029
83	.00040	23953	44461	47003	41870	53518	620
84	.00040	72434	80875	30731	29400	02807	212
85	0.00041	20916	17279	57256	55842	36745	565
86	.00041	69397	53674	15183	94343	97432	460
87	.00042	17878	90058	93118	18053	54630	094
88	.00042	66360	26433	79664	00122	08442	474
89	.00043	14841	62798	63426	13702	91993	809
90	0.00043	63322	99153	33009	31951	74106	900
91	.00044	11804	35497	77018	28026	61981	538
92	.00044	60285	71831	84057	75088	03872	894
93	.00045	08767	08155	42732	46298	91769	913
94	.00045	57248	44468	41647	14824	64073	705
95	0.00046	05729	80770	69406	53833	08275	940
96	.00046	54211	17062	14615	36494	63637	242
97	.00047	02692	53342	65878	35982	23865	578
98	.00047	51173	89612	11800	25471	39794	654
99	.00047	99655	25870	40985	78140	22062	307
100	0.00048	48136	62117	42039	67169	43788	898

TABLE 1.—VALUES OF SINE θ (*Continued*)

θ″	Sine θ							θ °	θ ′	θ ″
100	0.00048	48136	62117	42039	67169	43788	898	0	01	40
200	.00096	96272	10282	15256	89823	20807	032	0	03	20
300	.00145	44405	30541	53507	62744	90817	111	0	05	00
400	.00193	92535	08942	96004	59253	71238	703	0	06	40
500	0.00242	40660	31533	89995	70314	77452	941	0	08	20
600	.00290	88779	84361	93442	43460	76882	902	0	10	00
700	.00339	36892	53474	77698	21461	61448	455	0	11	40
800	.00387	84997	24920	30186	80679	43000	289	0	13	20
900	.00436	33092	84746	57080	69045	76345	248	0	15	00
1000	0.00484	81178	19001	85979	43598	14483	948	0	16	40
2000	.00969	61216	85978	39588	10784	88351	447	0	33	20
3000	.01454	38976	51582	65677	03848	45733	109	0	50	00
4000	.01939	13317	71824	37245	47571	94786	397	1	06	40
5000	0.02423	83101	10748	13776	78016	39085	971	1	23	20
6000	.02908	47187	43111	40688	85777	50013	596	1	40	00
7000	.03393	04437	57062	23604	67590	79056	606	1	56	40
8000	.03877	53712	56816	71148	99343	73318	846	2	13	20
9000	.04361	93873	65335	99978	17530	77209	944	2	30	00
10000	0.04846	23782	27002	95750	84955	84328	790	2	46	40
11000	.05330	42300	10298	23748	20045	37349	674	3	03	20
12000	.05814	48289	10475	82853	87480	16847	071	3	20	00
13000	.06298	40611	52237	96604	80984	34293	964	3	36	40
14000	.06782	18129	92409	35025	77020	37025	599	3	53	20
15000	0.07265	79707	22610	60962	00827	96120	115	4	10	00
16000	.07749	24206	71930	94626	23706	99519	970	4	26	40
17000	.08232	50492	09599	90078	02676	95188	826	4	43	20
18000	.08715	57427	47658	17355	80642	70837	473	5	00	00
19000	.09198	43877	43627	43983	86954	31224	866	5	16	40
20000	0.09681	08707	03179	09579	14761	20018	367	5	33	20
21000	.10163	50781	82801	87285	02823	74772	066	5	50	00
22000	.10645	68967	92468	25762	15451	10176	599	6	06	40
23000	.11127	62131	98299	65468	94977	71117	421	6	23	20
24000	.11609	29141	25230	22967	56665	23380	711	6	40	00
25000	0.12090	68863	59669	36994	06114	61572	998	6	56	40
26000	.12571	80167	52162	70034	84187	81870	530	7	13	20
27000	.13052	61922	20051	59154	84062	27895	489	7	30	00
28000	.13533	12997	50131	09826	39365	73063	912	7	46	40
29000	.14013	32264	01306	26511	51356	19346	678	8	03	20
30000	0.14493	18593	07246	73754	06813	03177	897	8	20	00
31000	.14972	70856	79039	61542	36681	02368	752	8	36	40
32000	.15451	87928	07840	48706	78550	96980	932	8	53	20
33000	.15930	68680	67522	58121	33757	81353	360	9	10	00
34000	.16409	11989	17323	97482	52220	48582	552	9	26	40
35000	0.16887	16729	04492	79443	35126	33030	004	9	43	20

TABLE 1.—VALUES OF SINE θ (*Continued*)

θ"	Sine θ							θ °	θ ′	θ ″
35000	0.16887	16729	04492	79443	35126	33030	004	9	43	20
36000	.17364	81776	66930	34885	17166	26769	314	10	00	00
37000	.17842	06009	35832	13114	76243	73816	845	10	16	40
38000	.18318	88305	38326	62779	19399	48689	692	10	33	20
39000	.18795	27544	00111	87296	09103	66159	291	10	50	00
40000	0.19271	22605	48089	68602	24054	35580	049	11	06	40
41000	.19746	72371	12997	53028	93175	20166	624	11	23	20
42000	.20221	75723	32037	93118	00611	09131	373	11	40	00
43000	.20696	31545	51505	39198	33167	44529	770	11	56	40
44000	.21170	38722	29410	74548	29811	16675	828	12	13	20
45000	0.21643	96139	38102	87975	95536	69617	940	12	30	00
46000	.22117	02683	66887	77654	59084	24833	467	12	46	40
47000	.22589	57243	24644	80057	85664	86355	610	13	03	20
48000	.23061	58707	42440	17845	01983	49292	939	13	20	00
49000	.23533	05966	76137	60553	51441	77436	051	13	36	40
50000	0.24003	97913	09005	91962	72430	91690	162	13	53	20
51000	.24474	33439	54323	77999	82076	32813	311	14	10	00
52000	.24944	11440	57981	29065	51653	08864	737	14	26	40
53000	.25413	30812	01078	50664	78138	55503	119	14	43	20
54000	.25881	90451	02520	76234	88988	37624	048	15	00	00
55000	0.26349	89256	21610	76070	64197	81812	046	15	16	40
56000	.26817	26127	60637	36254	21023	94984	500	15	33	20
57000	.27283	99966	67461	01504	82378	06002	119	15	50	00
58000	.27750	09676	38095	75871	39833	40833	418	16	06	40
59000	.28215	54161	19287	75199	26412	51393	960	16	23	20
60000	0.28680	32327	11090	25310	32801	73167	158	16	40	00
61000	.29144	43081	69434	99844	33369	63357	123	16	56	40
62000	.29607	85334	08699	91717	35320	12347	692	17	13	20
63000	.30070	57995	04273	12162	25471	35931	073	17	30	00
64000	.30532	59976	95113	11324	64497	20020	700	17	46	40
65000	0.30993	90193	86305	14396	67978	45929	734	18	03	20
66000	.31454	47561	51613	67280	17265	82039	423	18	20	00
67000	.31914	30997	36030	85779	60933	62815	731	18	36	40
68000	.32373	39420	58321	02334	99482	31479	140	18	53	20
69000	.32831	71752	13561	04313	91905	07868	057	19	10	00
70000	0.33289	26914	75676	57891	82749	34745	209	19	26	40
71000	.33746	03832	99974	11559	22352	97522	744	19	43	20
72000	.34202	01433	25668	73304	40996	14682	259	20	00	00
73000	.34657	18643	78407	55530	39759	36664	117	20	16	40
74000	.35111	54394	72788	81774	76892	14440	613	20	33	20
75000	0.35565	07618	14876	49311	58452	17291	041	20	50	00
76000	.36017	77248	04710	41724	85846	71617	039	21	06	40
77000	.36469	62220	38811	85553	70672	05417	247	21	23	20
78000	.36920	61473	12684	45119	98878	30071	688	21	40	00
79000	.37370	73946	23310	49660	11760	53564	587	21	56	40
80000	0.37819	98581	71642	46893	70567	45860	696	22	13	20

TABLE 1.—VALUES OF SINE θ (*Continued*)

θ″	Sine θ							θ °	θ ′	θ ″
80000	0.37819	98581	71642	46893	70567	45860	696	22	13	20
81000	.38268	34323	65089	77172	84599	84030	399	22	30	00
82000	.38715	80118	20000	62367	09516	75664	442	22	46	40
83000	.39162	34913	64139	03650	63151	45548	608	23	03	20
84000	.39607	97660	39156	82369	60433	91609	744	23	20	00
85000	0.40052	67311	03060	58179	36996	58697	610	23	36	40
86000	.40496	42820	32673	58653	12675	97568	048	23	53	20
87000	.40939	23145	26092	54575	41387	94119	105	24	10	00
88000	.41381	07245	05139	15146	02720	61105	513	24	26	40
89000	.41821	94081	17806	37332	13027	39853	214	24	43	20
90000	0.42261	82617	40699	43618	69784	89647	730	25	00	00
91000	.42700	71819	81471	42419	92477	42377	872	25	16	40
92000	.43138	60656	81253	45426	86252	32813	699	25	33	20
93000	.43575	48099	17079	36179	31028	12022	586	25	50	00
94000	.44011	33120	04304	84162	88601	12690	874	26	06	40
95000	0.44446	14694	99020	98745	23555	28775	780	26	23	20
96000	.44879	91802	00462	17278	50403	34733	143	26	40	00
97000	.45312	63421	53408	21708	49345	06908	387	26	56	40
98000	.45744	28536	50580	78044	36287	95557	841	27	13	20
99000	.46174	86132	35033	93056	29306	73135	623	27	30	00
100000	0.46604	35197	02538	82582	23487	64495	630	27	46	40
101000	.47032	74721	03962	45838	69080	27959	114	28	03	20
102000	.47460	03697	47640	40144	44030	52184	505	28	20	00
103000	.47886	21122	01743	50480	21260	80880	521	28	36	40
104000	.48311	25992	96638	48321	53464	63171	169	28	53	20
105000	0.48735	17311	27242	34196	33658	08586	089	29	10	00
106000	.49157	94080	55370	58433	38248	28214	527	29	26	40
107000	.49579	55307	12079	14582	20902	62875	705	29	43	20
108000	.50000	00000	00000	00000	00000	00000	000	30	00	00
109000	.50419	27170	95670	38115	69879	97569	601	30	16	40
110000	0.50837	35834	51855	56896	66444	69809	366	30	33	20
111000	.51254	25007	99865	18058	30874	18895	538	30	50	00
112000	.51669	93711	51862	91572	41254	63063	465	31	06	40
113000	.52084	40968	03169	70045	20754	27285	637	31	23	20
114000	.52497	65803	34560	17551	82577	11220	776	31	40	00
115000	0.52909	67246	14552	47529	36243	83473	826	31	56	40
116000	.53320	44328	01691	24346	56755	94519	073	32	13	20
117000	.53729	96083	46823	83184	07855	46267	707	32	30	00
118000	.54138	21549	95369	62875	12861	67817	392	32	46	40
119000	.54545	19767	89582	46372	81410	58369	706	33	03	20
120000	0.54950	89780	70806	03526	27803	74050	134	33	20	00
121000	.55355	30634	81722	30864	56553	30355	275	33	36	40
122000	.55758	41379	68592	83103	43050	11746	238	33	53	20
123000	.56160	21067	83492	91107	02043	40781	882	34	10	00
124000	.56560	68754	86538	61053	13764	48220	929	34	26	40
125000	0.56959	83499	48106	49567	67013	60694	550	34	43	20

TABLE 1.—VALUES OF SINE θ (*Continued*)

θ''	Sine θ							θ °	θ ′	θ ″
125000	0.56959	83499	48106	49567	67013	60694	550	34	43	20
126000	.57357	64363	51046	09610	80319	12826	158	35	00	00
127000	.57754	10411	92885	01914	76330	96100	449	35	16	40
128000	.58149	20712	88026	66790	10886	48582	988	35	33	20
129000	.58542	94337	69940	51134	96645	10259	519	35	50	00
130000	0.58935	30360	93344	85499	11787	32161	758	36	06	40
131000	.59326	27860	36382	06072	46974	18896	909	36	23	20
132000	.59715	85917	02786	16485	18521	60583	960	36	40	00
133000	.60104	03615	24042	84324	62520	00059	672	36	56	40
134000	.60490	80042	61541	67292	23380	84844	332	37	13	20
135000	0.60876	14290	08720	63941	60975	42898	164	37	30	00
136000	.61260	05451	93202	83957	23105	40752	806	37	46	40
137000	.61642	52625	78925	32951	64466	48319	867	38	03	20
138000	.62023	54912	68260	06777	39492	34865	251	38	20	00
139000	.62403	11417	04126	90368	54453	15852	926	38	36	40
140000	0.62781	21246	72098	56145	33886	93521	289	38	53	20
141000	.63157	83513	02497	57034	37819	90534	395	39	10	00
142000	.63532	97330	72485	09175	59238	43787	042	39	26	40
143000	.63906	61818	08141	59406	35866	55041	224	39	43	20
144000	.64278	76096	86539	32632	26434	09907	263	40	00	00
145000	0.64649	39292	37806	54213	29246	73007	645	40	16	40
146000	.65018	50533	47183	42513	59944	14209	006	40	33	20
147000	.65386	08952	57069	66782	55812	60900	376	40	50	00
148000	.65752	13685	69063	65554	35855	19951	813	41	06	40
149000	.66116	63872	45993	20773	18972	59028	767	41	23	20
150000	0.66479	58656	13937	82870	87022	42597	499	41	40	00
151000	.66840	97183	64242	42043	75159	18990	214	41	56	40
152000	.67200	78605	55522	40995	78662	60690	329	42	13	20
153000	.67559	02076	15660	24434	83393	53674	354	42	30	00
154000	.67915	66753	43793	20629	56024	70184	810	42	46	40
155000	0.68270	71799	12292	50354	70231	73649	024	43	03	20
156000	.68624	16378	68733	58572	96049	99617	538	43	20	00
157000	.68975	99661	37857	64222	41556	11776	983	43	36	40
158000	.69326	20820	23524	23499	08872	00800	829	43	53	20
159000	.69674	79032	10655	02045	10164	03957	504	44	10	00
160000	0.70021	73477	67168	51473	83772	77449	050	44	26	40
161000	.70367	03341	45905	85684	55809	28499	420	44	43	20
162000	.70710	67811	86547	52440	08443	62104	849	45	00	00

TABLE 2.—VALUES OF COSINE θ

θ″	Cosine θ						
1	0.99999	99999	88247	78473	04740	76217	925
2	.99999	99999	52991	13892	21725	33999	183
3	.99999	99998	94230	06257	59240	60726	215
4	.99999	99998	11964	55569	31098	02036	402
5	0.99999	99997	06194	61827	56633	61822	030
6	.99999	99995	76920	25032	60708	02230	248
7	.99999	99994	24141	45184	73706	43663	006
8	.99999	99992	47858	22284	31538	64776	987
9	.99999	99990	48070	56331	75639	02483	521
10	0.99999	99988	24778	47327	52966	51948	487
11	.99999	99985	77981	95272	16004	66592	202
12	.99999	99983	07681	00166	22761	58089	300
13	.99999	99980	13875	62010	36769	96368	596
14	.99999	99976	96565	80805	27087	09612	932
15	0.99999	99973	55751	56551	68294	84259	022
16	.99999	99969	91432	89250	40499	64997	267
17	.99999	99966	03609	78902	29332	54771	578
18	.99999	99961	92282	25508	25949	14779	165
19	.99999	99957	57450	29069	27029	64470	329
20	0.99999	99952	99113	89586	34778	81548	232
21	.99999	99948	17273	07060	56926	01968	655
22	.99999	99943	11927	81493	06725	19939	751
23	.99999	99937	83078	12885	02954	87921	772
24	.99999	99932	30724	01237	69918	16626	794
25	0.99999	99926	54865	46552	37442	75018	423
26	.99999	99920	55502	48830	40880	90311	490
27	.99999	99914	32635	08073	21109	47971	735
28	.99999	99907	86263	24282	24529	91715	471
29	.99999	99901	16386	97459	03068	23509	247
30	0.99999	99894	23006	27605	14175	03569	483
31	.99999	99887	06121	14722	20825	50362	106
32	.99999	99879	65731	58811	91519	40602	164
33	.99999	99872	01837	59876	00281	09253	432
34	.99999	99864	14439	17916	26659	49528	000
35	0.99999	99856	03536	32934	55728	12885	854
36	.99999	99847	69129	04932	78085	09034	439
37	.99999	99839	11217	33912	89853	05928	211
38	.99999	99830	29801	19876	92679	29768	179
39	.99999	99821	24880	62826	93735	65001	425
40	0.99999	99811	96455	62765	05718	54320	624
41	.99999	99802	44526	19693	46848	98663	540
42	.99999	99792	69092	33614	40872	57212	513
43	.99999	99782	70154	04530	17059	47393	936
44	.99999	99772	47711	32443	10204	44877	711
45	0.99999	99762	01764	17355	60626	83576	705
46	.99999	99751	32312	59270	14170	55646	175
47	.99999	99740	39356	58189	22204	11483	199
48	.99999	99729	22896	14115	41620	59726	082
49	.99999	99717	82931	27051	34837	67253	750
50	0.99999	99706	19461	96999	69797	59185	136

TABLE 2.—VALUES OF COSINE θ (*Continued*)

θ″	Cosine						
50	0.99999	99706	19461	96999	69797	59185	136
51	.99999	99694	32488	23963	19967	18878	549
52	.99999	99682	22010	07944	64337	87931	033
53	.99999	99669	88027	48946	87425	66177	709
54	.99999	99657	30540	46972	79271	11691	105
55	0.99999	99644	49549	02025	35439	40780	481
56	.99999	99631	45053	14107	57020	27991	125
57	.99999	99618	17052	83222	50628	06103	652
58	.99999	99604	65548	09373	28401	66133	283
59	.99999	99590	90538	92563	08004	57329	106
60	0.99999	99576	92025	32795	12624	87173	336
61	.99999	99562	70007	30072	70975	21380	550
62	.99999	99548	24484	84399	17292	83896	920
63	.99999	99533	55457	95777	91339	56899	420
64	.99999	99518	62926	64212	38401	80795	034
65	0.99999	99503	46890	89706	09290	54219	942
66	.99999	99488	07350	72262	60341	34038	695
67	.99999	99472	44306	11885	53414	35343	377
68	.99999	99456	57757	08578	55894	31452	757
69	.99999	99440	47703	62345	40690	53911	423
70	0.99999	99424	14145	73189	86236	92488	905
71	.99999	99407	57083	41115	76491	95178	788
72	.99999	99390	76516	66127	00938	68197	809
73	.99999	99373	72445	48227	54584	75984	941
74	.99999	99356	44869	87421	37962	41200	462
75	0.99999	99338	93789	83712	57128	44725	018
76	.99999	99321	19205	37105	23664	25658	666
77	.99999	99303	21116	47603	54675	81319	908
78	.99999	99284	99523	15211	72793	67244	709
79	.99999	99266	54425	39934	06172	97185	505
80	0.99999	99247	85823	21774	88493	43110	195
81	.99999	99228	93716	60738	58959	35201	123
82	.99999	99209	78105	56829	62299	61854	047
83	.99999	99190	38990	10052	48767	69677	091
84	.99999	99170	76370	20411	74141	63489	687
85	0.99999	99150	90245	87911	99724	06321	506
86	.99999	99130	80617	12557	92342	19411	372
87	.99999	99110	47483	94354	24347	82206	163
88	.99999	99089	90846	33305	73617	32359	705
89	.99999	99069	10704	29417	23551	65731	647
90	0.99999	99048	07057	82693	63076	36386	323
91	.99999	99026	79906	93139	86641	56591	604
92	.99999	99005	29251	60760	94221	96817	736
93	.99999	98983	55091	85561	91316	85736	167
94	.99999	98961	57427	67547	88950	10218	353
95	0.99999	98939	36259	06724	03670	15334	564
96	.99999	98916	91586	03095	57550	04352	664
97	.99999	98894	23408	56667	78187	38736	887
98	.99999	98871	31726	67445	98704	38146	598
99	.99999	98848	16540	35435	57747	80435	036
100	0.99999	98824	77849	60641	99489	01648	050

TABLE 2.—VALUES OF COSINE θ (*Continued*)

θ''	Cosine θ							θ °	′	″
100	0.99999	98824	77849	60641	99489	01648	050	0	01	40
200	.99999	95299	11426	04859	14618	69087	718	0	03	20
300	.99999	89423	00812	19524	30450	81847	258	0	05	00
400	.99999	81196	46146	16090	05668	14138	802	0	06	40
500	0.99999	70619	47621	30585	47944	02697	103	0	08	20
600	.99999	57692	05486	23611	59460	12436	124	0	10	00
700	.99999	42414	20044	80335	52572	10605	823	0	11	40
800	.99999	24785	91656	10483	35623	63183	580	0	13	20
900	.99999	04807	20734	48331	68908	70286	798	0	15	00
1000	0.99998	82478	07749	52697	90782	60445	306	0	16	40
2000	.99995	29915	07226	15330	04692	98023	894	0	33	20
3000	.99989	42319	27107	52254	64532	27481	627	0	50	00
4000	.99981	19704	48501	39893	94719	26234	634	1	06	40
5000	0.99970	62090	04913	20525	42015	08166	159	1	23	20
6000	.99957	69500	82200	57696	26607	63405	281	1	40	00
7000	.99942	41967	18514	93368	05324	11432	941	1	56	40
8000	.99924	79525	04230	06928	80243	59014	703	2	13	20
9000	.99904	82215	81857	76240	37162	19403	330	2	30	00
10000	0.99882	50086	45950	40919	49149	63375	233	2	46	40
11000	.99857	83189	42990	68081	30755	65278	093	3	03	20
12000	.99830	81582	71268	20804	78207	08783	278	3	20	00
13000	.99801	45329	80743	29609	80108	59131	055	3	36	40
14000	.99769	74499	72897	67266	31651	24437	112	3	53	20
15000	0.99735	69167	00572	27286	33071	52804	468	4	10	00
16000	.99699	29411	67792	06480	00016	81034	629	4	26	40
17000	.99660	55319	29577	91987	59491	03072	423	4	43	20
18000	.99619	46980	91745	53229	50104	02473	888	5	00	00
19000	.99576	04493	10691	39246	89358	35953	664	5	16	40
20000	0.99530	27957	93165	81936	13607	09688	502	5	33	20
21000	.99482	17482	96033	05710	38033	04378	624	5	50	00
22000	.99431	73181	26018	44152	24463	29729	806	6	06	40
23000	.99378	95171	39442	64251	83970	77594	519	6	23	20
24000	.99323	83577	41942	98854	78955	52193	704	6	40	00
25000	0.99266	38528	88181	87975	25671	45608	280	6	56	40
26000	.99206	60160	81542	29659	32897	60508	774	7	13	20
27000	.99144	48613	73810	41114	45575	26928	563	7	30	00
28000	.99080	04033	64845	30850	93672	86613	503	7	46	40
29000	.99013	26572	02235	82611	76227	01884	454	8	03	20
30000	0.98944	16385	80944	51897	38370	64936	939	8	20	00
31000	.98872	73637	42938	75922	25125	21270	174	8	36	40
32000	.98798	98494	76808	97870	19733	65138	328	8	53	20
33000	.98722	91131	17374	06345	96272	07825	437	9	10	00
34000	.98644	51725	45273	90950	36130	58227	655	9	26	40
35000	0.98563	80461	86549	14936	75625	91705	341	9	43	20

TABLE 2.—VALUES OF COSINE θ (*Continued*)

θ″	Cosine θ							θ °	θ ′	θ ″
35000	0.98563	80461	86549	14936	75625	91705	341	9	43	20
36000	.98480	77530	12208	05936	67430	24589	523	10	00	00
37000	.98395	43125	37780	65772	51599	70530	389	10	16	40
38000	.98307	77448	22860	00405	42693	48954	215	10	33	20
39000	.98217	80704	70630	71096	47717	68768	433	10	50	00
40000	0.98125	53106	27384	67889	35337	51430	954	11	06	40
41000	.98030	94869	82024	06552	79906	21844	498	11	23	20
42000	.97934	06217	65551	50151	04288	24636	922	11	40	00
43000	.97834	87377	50547	56440	43137	64919	949	11	56	40
44000	.97733	38582	50635	52320	43159	80711	030	12	13	20
45000	0.97629	60071	19933	36597	08864	89605	428	12	30	00
46000	.97523	52087	52493	12346	91344	82532	502	12	46	40
47000	.97415	14880	81727	50199	03601	37006	148	13	03	20
48000	.97304	48705	79823	83883	28851	72784	696	13	20	00
49000	.97191	53822	57145	39421	67968	63170	943	13	36	40
50000	0.97076	30496	61619	99370	48705	41634	248	13	53	20
51000	.96958	78998	78116	03549	92542	09959	624	14	10	00
52000	.96838	99605	27805	87728	04796	72433	550	14	26	40
53000	.96716	92597	67516	61755	20007	10311	466	14	43	20
54000	.96592	58262	89068	28674	97431	99728	897	15	00	00
55000	0.96465	96893	18599	46367	20778	00334	742	15	16	40
56000	.96337	08786	15880	33308	11859	45689	290	15	33	20
57000	.96205	94244	73613	20062	19774	02922	903	15	50	00
58000	.96072	53577	16720	48149	95257	00092	449	16	06	40
59000	.95936	87097	01620	17965	04093	15820	317	16	23	20
60000	0.95798	95123	15488	87443	73747	66956	755	16	40	00
61000	.95658	77979	75512	23219	03657	05217	438	16	56	40
62000	.95516	35996	28123	06021	01829	41469	934	17	13	20
63000	.95371	69507	48226	92114	38470	64600	258	17	30	00
64000	.95224	78853	38415	32593	31211	28441	795	17	46	40
65000	0.95075	64379	28166	52382	96088	72745	030	18	03	20
66000	.94924	26435	73033	90826	13672	60314	740	18	20	00
67000	.94770	65378	53822	05762	70539	00165	703	18	36	40
68000	.94614	81568	75750	43038	42633	44150	010	18	53	20
69000	.94456	75372	67604	73408	88844	60829	404	19	10	00
70000	0.94296	47161	80875	98833	20272	84944	114	19	26	40
71000	.94133	97312	88887	30181	03151	04064	764	19	43	20
72000	.93969	26207	85908	38405	41092	77324	732	20	00	00
73000	.93802	34233	86257	81262	65235	97115	007	20	16	40
74000	.93633	21783	23393	07689	38851	27219	288	20	33	20
75000	0.93461	89253	48988	41975	56026	15508	867	20	50	00
76000	.93288	37047	32000	49900	82050	33097	417	21	06	40
77000	.93112	65572	57721	89030	46047	93683	301	21	23	20
78000	.92934	75242	26822	45395	54160	27564	276	21	40	00
79000	.92754	66474	54378	58810	44112	07511	693	21	56	40
80000	0.92572	39692	68890	39109	49227	43644	059	22	13	20

TABLE 2.—VALUES OF COSINE θ (*Continued*)

θ″	Cosine θ							θ °	θ ′	θ ″
80000	0.92572	39692	68890	39109	49227	43644	059	22	13	20
81000	.92387	95325	11286	75612	81831	89396	788	22	30	00
82000	.92201	33805	33918	42159	82417	51005	049	22	46	40
83000	.92012	55571	99539	00077	11892	01720	896	23	03	20
84000	.91821	61068	80274	01475	89614	15314	637	23	20	00
85000	0.91628	50744	56577	95301	99669	10379	085	23	36	40
86000	.91433	25053	16179	38590	01894	09911	083	23	53	20
87000	.91235	84453	53014	15400	92458	55321	636	24	10	00
88000	.91036	29409	66146	65950	61269	69701	259	24	26	40
89000	.90834	60390	58679	28464	90047	54815	463	24	43	20
90000	0.90630	77870	36649	96324	25526	56754	317	25	00	00
91000	.90424	82328	07917	93089	46829	87244	356	25	16	40
92000	.90216	74247	81037	68027	24559	96346	896	25	33	20
93000	.90006	54118	64121	14782	41492	26925	298	25	50	00
94000	.89794	22434	63688	15871	10879	25644	859	26	06	40
95000	0.89579	79694	83505	15696	88208	37774	595	26	23	20
96000	.89363	26403	23412	24819	25741	86866	655	26	40	00
97000	.89144	63068	78138	58231	66235	63600	156	26	56	40
98000	.88923	90205	36106	10433	12823	63874	580	27	13	20
99000	.88701	08331	78221	70105	46098	83037	517	27	30	00
100000	0.88476	17971	76657	77234	86857	64728	642	27	46	40
101000	.88249	19653	93621	25544	23738	08546	285	28	03	20
102000	.88020	13911	80111	13129	39007	65608	480	28	20	00
103000	.87789	01283	74664	44219	72983	15935	547	28	36	40
104000	.87555	82313	02090	85010	67925	63258	589	28	53	20
105000	0.87320	57547	72195	76542	25687	54324	677	29	10	00
106000	.87083	27540	78492	07624	99832	00274	584	29	26	40
107000	.86843	92849	96900	50841	22332	32894	675	29	43	20
108000	.86602	54037	84438	64676	37231	70752	936	30	00	00
109000	.86359	11671	77898	64861	78734	18410	727	30	16	40
110000	0.86113	66323	92513	68036	89047	11923	137	30	33	20
111000	.85866	18571	20613	10865	21839	08591	569	30	50	00
112000	.85616	68995	30266	47765	20353	68472	192	31	06	40
113000	.85365	18182	63916	30442	94966	76849	576	31	23	20
114000	.85111	66724	36999	72440	53230	15594	884	31	40	00
115000	0.84856	15216	36559	01939	56147	29489	679	31	56	40
116000	.84598	64259	19841	06085	87513	91409	795	32	13	20
117000	.84339	14458	12885	70127	28568	05827	572	32	30	00
118000	.84077	66423	09103	14682	27867	79545	790	32	46	40
119000	.83814	20768	67840	34483	46190	26250	481	33	03	20
120000	0.83548	78114	12936	41965	38261	70019	584	33	20	00
121000	.83281	39083	31267	19092	07224	03480	631	33	36	40
122000	.83012	04304	71278	80845	33858	88619	260	33	53	20
123000	.82740	74411	41510	53820	40664	30805	183	34	10	00
124000	.82467	50041	09106	73401	00852	96826	926	34	26	40
125000	0.82192	31835	98318	03011	44152	92055	530	34	43	20

TABLE 2.—VALUES OF COSINE θ (Continued)

θ″	Cosine θ							θ °	θ ′	θ ″
125000	0.82192	31835	98318	03011	44152	92055	530	34	43	20
126000	.81915	20442	88991	78968	44883	85916	843	35	00	00
127000	.81636	16513	15051	84481	03093	23590	596	35	16	40
128000	.81355	20702	62967	56371	46508	49682	892	35	33	20
129000	.81072	33671	70212	28115	89634	80549	570	35	50	00
130000	0.80787	56085	23711	12827	86442	99734	483	36	06	40
131000	.80500	88612	58278	29833	04691	39261	663	36	23	20
132000	.80212	31927	55043	78508	32948	91933	925	36	40	00
133000	.79921	86708	39869	63083	05777	40147	899	36	56	40
134000	.79629	53637	81755	72124	98229	69134	519	37	13	20
135000	0.79335	33402	91235	16457	97769	61501	299	37	30	00
136000	.79039	26695	18759	29283	09861	70580	147	37	46	40
137000	.78741	34210	53072	32298	92755	88165	015	38	03	20
138000	.78441	56649	19575	71641	47347	24386	379	38	20	00
139000	.78139	94715	78682	27488	09366	91314	549	38	36	40
140000	0.77836	49119	24160	01194	03499	36116	485	38	53	20
141000	.77531	20572	81465	83854	22268	34155	507	39	10	00
142000	.77224	09794	06069	10206	86630	78636	736	39	26	40
143000	.76915	17504	81765	01819	30109	64085	003	39	43	20
144000	.76604	44431	18978	03520	23926	50555	417	40	00	00
145000	0.76291	91303	53055	17066	26907	30247	919	40	16	40
146000	.75977	58856	42549	36054	00873	36254	422	40	33	20
147000	.75661	47828	67492	86112	79740	94670	113	40	50	00
148000	.75343	58963	27660	74436	18579	08569	961	41	06	40
149000	.75023	93007	40824	52733	77363	79999	078	41	23	20
150000	0.74702	50712	40995	97708	13061	51183	367	41	40	00
151000	.74379	32833	76661	13184	62921	28215	260	41	56	40
152000	.74054	40131	09004	58045	01400	11765	967	42	13	20
153000	.73727	73368	10124	04138	42933	94982	317	42	30	00
154000	.73399	33312	61235	28366	42745	16636	468	42	46	40
155000	0.73069	20736	50867	43161	17992	18861	828	43	03	20
156000	.72737	36415	73048	69598	71764	17663	816	43	20	00
157000	.72403	81130	25482	57411	52651	38384	266	43	36	40
158000	.72068	55664	07714	56187	22826	08402	286	43	53	20
159000	.71731	60805	19289	42062	37697	70109	592	44	10	00
160000	0.71392	97345	57899	04242	60206	36824	553	44	26	40
161000	.71052	66081	17520	95702	42639	44831	623	44	43	20
162000	.70710	67811	86547	52440	08443	62104	849	45	00	00

BOTANY.—*Ferns new to the Cuban Flora.*[1] WILLIAM R. MAXON, National Museum.

In the course of continued botanical exploration of eastern Cuba, Brother Léon collected extensively in the high Sierra Maestra, Oriente Province, during July of the present year and ascended Pico Turquino, the culminating point of the range, which has an altitude of approximately 2,300 meters. His collections were sent to the New York Botanical Garden, from which institution a set of the ferns has been forwarded to the National Museum for identification by the writer. Since the region is almost untouched botanically this material proves of exceptional interest, containing several new species as well as numerous others that are rare in Cuba or have been known heretofore only from the Blue Mountains of Jamaica. These are described and listed in the present paper.

The discovery of a pronounced montane Jamaican element at similar elevations in Cuba is not altogether unexpected, and the definite records of extended ranges here given will lead to a certain modification of the current idea of Jamaica as a highly endemic center, at least so far as ferns are concerned. With increasing collections from the high Sierra Maestra an analysis of this relation and of the elements common to Cuba and Hispaniola should prove of the highest interest from several points of view.

In addition to records afforded by Brother Léon's collection of 1922 there are included a few based upon material collected by Brother Léon and his associates a year or two earlier in other parts of the Sierra Maestra, mainly at a lower altitude.

CYATHEACEAE

Culcita coniifolia (Hook.) Maxon.

Near top of Pico Turquino, among shrubs (11155).

This is the only Cuban material seen by the writer. Known from Hispaniola and Jamaica, and on the continent from Mexico to Brazil and Ecuador.

Cyathea araneosa Maxon, N. Amer. Fl. **16**: 74. 1909.

Sierra Maestra (11089).

Described from the Gran Piedra, Oriente, Cuba, on specimens collected by the writer (no. 4035), and since gathered by other collectors. The present specimen is the most completely fertile one seen, the segments throughout the pinnae all bearing 4 to 6 pairs of sori, instead of 1 to 3 basal pairs. The specific name was unfortunately chosen, inasmuch as the delicate, whitish-araneose inner border of the indusium, though evident enough in the

[1] Published by permission of the Secretary of the Smithsonian Institution. Received October 20, 1922.

type specimens, disappears at a very early stage, upon the ripening of the sporangia. Only the merest trace is discernible in the other specimens.

Cyathea producta Maxon, sp. nov.

Caudex erect, 4 to 6 meters high; fronds apparently ample; stipe 75 cm. long, olivaceous from a brown densely scurfy base, aculeate throughout, the spines numerous, 1 to 2 mm. long, conical, straight or antrorsely curved; basal part of stipe persistently paleaceous, the scales densely imbricate, 2 to 3.5 cm. long, acicular-caudate from a lanceolate base, atropurpureous, highly lustrous, with narrow yellowish brown, scarious, subentire borders; blade at least 1 meter broad, subtripinnate; rachis and middle pinnae wanting; basal pinnae oblong, 43 cm. long, 18 cm. broad, abruptly short-acuminate, long-petiolate (3 cm.), the secondary rachis dull olivaceous, closely yellowish-strigose above, beneath laxly and sparsely yellowish-hirsutulous, muricate toward the base; pinnules about 17 pairs, slightly apart, sessile or nearly so, 9 to 11 cm. long, 14 to 18 mm. broad, linear-oblong, in the apical third abruptly acuminate and conspicuously attenuate-caudate (the attenuate tip 2.5 to 3.5 cm. long), pinnatifid to about 1 mm. from the costa, the costa yellowish-strigose above, beneath laxly glandular-puberulous and deciduously paleaceous, the scales membranous, yellowish brown, broadly ovate, hair-pointed, subbullate, caducous; segments 14 to 16 pairs, oblong, rounded-obtuse, broadly connected by their strongly dilatate bases, 7 to 10 mm. long, 3.5 mm. broad at their middle, 5 mm. broad at base, spreading, falcate, membrano-herbaceous, glabrous above except for 1 to 3 stiff spinous hairs near the apex, thinly hirsute beneath along and between the veins to the freely long-ciliate, broadly crenate, slightly recurved margin; costules minutely paleaceous beneath, the scales like those of the costae; veins 8 or 9 pairs, acutely once forked near the base; sori 5 to 7 pairs, borne against the costa; indusia globose, transparent, membranous, rupturing irregularly; receptacle large, dark, depressed; paraphyses numerous, short, griseous-hyaline.

Type in the U. S. National Herbarium, no. 1,049,972, collected along a small stream near Palma Mocha Peak, Sierra Maestra, Oriente, Cuba, at 1,300 meters altitude, July, 1922, by Brother Léon (no. 11181).

In minute characters, such as the structure and disposition of hairs and scales upon the under surface of the blade, *C. producta* is most nearly related to *C. dissoluta* Baker, a rare plant of the Blue Mountain region of Jamaica, at 1,500 to 1,800 meters altitude. That species differs notably in having the pinnules closer, shorter (5 to 8 cm. long), and merely acuminate, the segments close, not at all dilatate, and not ciliate, the veins very oblique, partly simple, and running to obliquely crenate marginal teeth, and the scales of the costae and costules beneath highly colored and lustrous. Among related species *C. producta* is readily distinguished by its abruptly caudate pinnules alone.

Cyathea pubescens Mett.

Pico Turquino; trunk 4 to 6 meters tall (11151).

New to Cuba. Known heretofore from the mountains of Porto Rico, Hispaniola and Jamaica (the original region). Variable and perhaps needing segregation.

GLEICHENIACEAE

Dicranopteris furcata (L.) Underw.

Pico Turquino (11106).

The specimens are referred tentatively to this species, which Underwood

reports only from the Lesser Antilles (Martinique, Guadeloupe, and St. Kitts). The Cuban plant is essentially like recent Haitian specimens (*Leonard* 4273, 4273a), which will be discussed shortly in reporting on Mr. Leonard's collections.

Dicranopteris jamaicensis Underw. Bull. Torrey Club **34:** 258. 1907.

Northwestern spur of Pico Turquino, altitude 1,900 meters (11112).

Known hitherto only from Jamaica, where it is abundant at 1,600 to 2,225 meters, forming extensive thickets on the half-open ridges, along with *D. palmata*.

Dicranopteris leonis Maxon, sp. nov.

Plant of medium size, sparingly branched; rhizome not seen; primary leaf-axis (incomplete) olivaceous, mottled with brown, about 3 mm. thick, dull, deciduously scurfy-paleaceous. Primary branches apparently 1 or 2 pairs, 35 to 40 cm. long, twice pseudodichotomous, the included buds all dormant, the scales firm, up to 7 mm. long, narrowly deltoid, flexuous at the long-attenuate apex, bright castaneous and lustrous with pale borders, or paler and concolorous, the friable borders obliquely and laxly long-ciliate; first internode of the branches 2 to 3.5 cm. long, naked, subtended by 1 or 2 small segments; second internodes 2 to 8 cm. long, diverging at an angle of 60 to 80°, completely pectinate except at the outer side near the base, the lower segments gradually shorter; pinnae diverging at an angle of 60°, linear-lanceolate, 25 to 32 cm. long, 3.5 to 5 cm. broad, abruptly narrowed at the base, attenuate at the apex, pectinate throughout, cut nearly to the rachis, the sinuses linear, acute; rachises of pinnae brownish or (in the outer part) greenish, persistently paleaceous beneath, the scales spreading, light castaneous, firm, freely long-ciliate; segments 90 or more on each side, close, linear, 1.8 to 2.8 cm. long, 4 mm. broad at the base, 3 to 3.5 mm. broad at the middle, acutish or narrowly obtuse, herbaceous, minutely pale-papillate beneath; margins entire, narrowly revolute; veins 30 to 35 pairs, close, once forked, green, elevated both above and beneath, these and the strongly elevated, stramineous costae minutely paleaceous beneath, the scales castaneous, reduced, substellate, with firm spreading cilia, minute ones extending sparingly almost to the margin, 4 or 5 larger ones invariably borne close against the leaf surface from the base of the receptacle of the sori in a close radiating indusium-like group, the scales otherwise all distinct, never forming a tomentum or obscuring the leaf surface; sori mostly 4-sporangiate, inframedial.

Type in the U. S. National Herbarium, no. 1,049,896, collected in the Turquino region of the high Sierra Maestra, Oriente, Cuba, July, 1922, by Brother Léon (no. 11092). The description is partly drawn from another specimen of the same number in the Underwood Herbarium, New York Botanical Garden.

In gross structural characters *D. leonis* is not very unlike *D. palmata* (Schaffn.) Underw., *D. mellifera* (Christ) Underw., and *D. brittonii* Maxon, in all of which the stellate scales of the under surface are very greatly reduced and truly capillary, even flaccid. In the presence and distribution of firm true scales beneath it is nearer *D. longipinnata* (Hook.) Maxon, of Surinam, but the scales are utterly different in color and structure.[2]

[2] Cfr. Contr. U. S. Nat. Herb. 24: 47–49. 1922.

POLYPODIACEAE

Elaphoglossum inaequalifolium (Jenman) C. Chr.

Pico Turquino, on trees (11166).

Described from Jamaica and known heretofore only from that island, where it is an abundant high-mountain species.

Polypodium gramineum Swartz.

Palma Mocha Peák, Sierra Maestra, at 1,400 meters elevation (11160).

Apparently not heretofore reported from Cuba. Agreeing closely with the present specimens are small plants collected on or near Pico Turquino by S. H. Hamilton in 1902. Both collections differ uniformly from the typical Jamaican plant in having much smaller and more delicate fronds, the stipes being more slender and the blades only 1 to 2 mm. broad, of thinner substance, and with some of the veins simple to the marginal connecting-vein; but in minute structural characters, such as those afforded by the rhizome scales and the once-forked glandular hairs of the leaf margin, the agreement is too close to justify the segregation of the Cuban plants as a distinct species. The extremes in width of blade do not, however, overlap. In Jamaica *P. gramineum* is abundant in the Blue Mountain region at 750 to 1,700 meters altitude.

Polypodium jenmani Underw.

East of Palma Mocha, Sierra Maestra, at 1,300 meters altitude, on tree trunks along a small stream (11101). Loma del Gato and vicinity, Cobre Range, Sierra Maestra, December, 1920, *Clement* 370.

New to Cuba, being known otherwise only from Jamaica, where it is very rare in the eastern part of the island at 500 to 900 meters elevation (*Maxon* 961, 1535; *Underwood* 2606; *Maxon & Killip* 173). The relationship is with *P. flexuosum* Maxon, of Cuba, which it resembles in scale structure.

Polypodium calvum Maxon, sp. nov.

Plants epiphytic, the fronds numerous, subfasciculate, rigidly ascending, 10 to 20 cm. long. Rhizome oblique or short-creeping, 1 cm. long or more, 3 or 4 mm. thick, coarsely long-radicose beneath, conspicuously paleaceous above, the scales ascending, loosely imbricate, 2.5 to 3 mm. long, 0.5 to 0.8 mm. broad, narrowly oblong-lanceolate, long-attenuate, attached just above the rounded subcordate base, entire, conspicuously clathrate, the cells with strongly sclerotic, dark reddish brown lateral walls, the outer walls pale yellowish, hyaline, greatly depressed; stipes short (0.5 to 1.5 cm. long), brown, nonsetose, bearing a few short branched glandular hairs, narrowly greenish-alate ventrally, the wings brownish with age; blades pinnatisect, 10 to 18 cm. long, 1 to 1.5 cm. broad near the middle, evenly attenuate in both directions, the apex not produced, the rachis nearly concealed above, beneath very prominent, black, lustrous, nonsetose, bearing a few branched glandular hairs, these evident mainly in the sinuses; pinnae 35 to 50 pairs, contiguous but not joined, spreading, the middle ones oblong or slightly triangular-oblong, broadest at base (3 to 4 mm.), rounded-obtuse or rarely acutish, rigidly coriaceous, nearly plane, entire, opaque, pale beneath, the venation wholly concealed; lower pinnae gradually shorter, triangular, the lowermost ones broader than long, short-decurrent; midveins of pinnae decurved at base, subflexuous; veins of larger pinnae 4 or 5 pairs, all but the proximal basal one diverging at about 45°, simple, ending in minute depressed-punctiform hydathodes remote from the margin; sori 3 or 4 pairs,

large, borne half way to the margin; sporangia numerous, glabrous, sometimes concealing 2 or 3 minute reddish setiform hairs.

Type in the U. S. National Herbarium, no. 1,049,931, collected in the high Sierra Maestra, Oriente, Cuba, in July, 1922, by Brother Léon (no. 11131). Collected also in the vicinity of Loma del Gato, Cobre Range, Sierra Maestra, altitude 1,100 meters, by Léon, Clement, and Roca (no. 10504).

A member of the group of *P. moniliforme* Lag., differing from the typical Jamaican form of that species in its short rhizome, its thick, short, rigid stipes, its numerous, mostly oblong pinnae, and its dark, heavily sclerotic rhizome scales. It is more nearly related to continental forms that are still erroneously retained in *P. moniliforme*.

Polypodium senile Fée.

Pico Turquino, on trees (11127).

New to the West Indian flora. Specimens are at hand from Costa Rica, Panama, Columbia, and Venezuela.[3]

Polypodium sherringii Baker.

Pico Turquino (11115).

Known hitherto only from the original collection, which came from the Newton District, Port Royal Mountains, Jamaica, at 1,200 to 1,500 meters altitude. This has recently been discussed by the writer.[4] The present specimens, which agree absolutely with a photograph of the type, show that the relationship with *P. basiattenuatum* Jenman is much more remote than previously supposed, Jenman's redescription[5] being accurate in every respect. The rigid, spongiose, dark green leaf-substance, with few, rigid, dark brown setae, the distant, oblique, decurrent lobes, and the decurrent foliaceous wing arising from the basal lobes at once distinguish this diminutive plant.

Cheilanthes harrisii Maxon, Contr. U. S. Nat. Herb. **24**: 51. 1922.

High Sierra Maestra (11184).

Known previously only from the vicinity of Cinchona, Jamaica, at 1,500 meters elevation. Allied to *C. marginata* H. B. K.

Paesia viscosa St. Hil.

Sierra Maestra, at 1,300 meters elevation; in woods (11159).

New to Cuba. An andine species of continental America, known hitherto in the West Indies only from the higher peaks of the Blue Mountains of Jamaica.

Psilogramme cubensis Maxon, sp. nov.

Rhizome stout, decumbent, 6 cm. long, 1.5 to 2 cm. thick (including the imbricate stipe-bases of old fronds), with numerous coarse wiry roots; rhizome hairs concealed, about 1.5 mm. long, dark purplish brown, opaque, rigid, simple, turgid, septate. Fronds several, clustered, arching, 40 to 60 cm. long; stipes nearly straight above the curved base, 20 to 28 cm. long, dark purplish brown, subscabrous, at first thinly short-villous with flattish septate hairs; blades oblong-lanceolate, acuminate, 20 to 32 cm. long, 8 to 13 cm. broad, subtripinnate, the primary rachis similar to the stipe, more freely villous, lightly flexuous throughout; larger primary pinnae 8 or 9 on each side, alternate, slightly oblique, subfalcate, inequilateral, those of the basal third the largest, triangular, acutish, 4 to 7 cm. long, 3 to 4.5 cm. broad,

[3] Cfr. Contr. U. S. Nat. Herb. **13**: 43. 1909.

[4] Contr. U. S. Nat. Herb. **17**: 552. 1916.

[5] Bull. Bot. Dept. Jamaica II. **4**: 113. 1897.

short-stalked (2 to 3 mm.), fully pinnate at base, the flexuous secondary rachis greenish-alate outward, bearing numerous pale, spreading, glistening, septate hairs; pinnules of larger pinnae 7 or 8 pairs below the pinnately lobed apex, pinnately parted, or the large basal ones fully pinnate at the base, with 4 or 5 pairs of spreading segments; larger segments in general broadly cuneate or cuneate-rhombic, 5 to 8 mm. long, 3 to 5 mm. broad (the base as broad as the common wing), obliquely cleft into 2 or 3 lobes, these simple or shallowly bilobate at tip; ultimate lobes 1.7 to 2 mm. broad; segments bright green, delicately membrano-herbaceous, bearing numerous stiff oblique tawny hairs above (both on and between the veins), the hairs of the lower side whitish, spreading, often gland-tipped, borne mainly on the veins; venation evident, the branches ending in the minutely emarginate tips of the lobes; sporangia relatively few, falling far short of the tips of the lobes, not long-decurrent.

Type in the U. S. National Herbarium, no. 1,049,913, collected on Pico Turquino, Sierra Maestra, Oriente, Cuba, in July, 1922, by Brother Léon (no. 11111).

A close ally of *Psilogramme chiapensis* Maxon,[6] of Mexico, belonging to the group of *P. hirta* and *P. glandulosa*, of South America. That species is similar to *P. cubensis* in structure, but differs in its much smaller pinnules and narrower segments (the ultimate lobes mostly 1 mm. broad, or less), and in its more copious hairy covering, this largely of a distinctly glandular type.

Asplenium diplosceuum Hieron. Hedwigia **60**: 232. 1918.

Loma del Gato and vicinity, Cobre Range, Sierra Maestra, at 1,000 meters altitude; in woods (*Léon, Clement & Roca* 10179).

Founded on Wright's no. 849, collected in some part of eastern Cuba, and known heretofore only on material of that collection.

Plagiogyria semicordata (Presl) Christ.

Near Pico Turquino (11126).

Apparently new to Cuba. It occurs on the summit of Blue Mountain Peak, Jamaica, altitude 2,225 meters, and on the continent from Mexico to the Andes of South America.

Struthiopteris shaferi Broadh. Bull. Torrey Club **39**: 374. 1912.

Slopes of Pico Turquino, at 1,800 to 1,900 meters altitude (11148).

Originally described from much smaller specimens, collected at Camp La Gloria, south of Sierra Moa, Oriente, Cuba, by J. A. Shafer (no. 8106). The present specimens are about 1 meter high and apparently represent a full development of the species.' The sterile blade tapers gradually in the lower third, the lowermost pinnae being less than 1 mm. long. In other respects the plant agrees with the original material, the form of the sterile pinnae being especially distinctive.

Dryopteris grisebachii (Baker) Kuntze.

Near Palma Mocha, Sierra Maestra, at 1,300 meters altitude, along banks of small stream (11137). Vicinity of Loma del Gato, Cobre Range, Sierra Maestra, altitude 1,050 meters, in forest (*Léon, Clement & Roca* 10169).

Known from Cuba otherwise, apparently, only on Wright's no. 1055, the type collection. It occurs sparingly in the Blue Mountain region of Jamaica at elevations of 750 to 1,500 meters.

[6] Bull. Torrey Club **42**: 81. 1915.

Dryopteris hemiptera Maxon, Contr. U. S. Nat. Herb. **24:** 59. 1922.

Ridge of the Sierra Maestra, at 1,300 meters elevation, in forest (11133). Cobre range of the Sierra Maestra (*Léon, Clement & Roca* 10311, 10409, 10486).

When described this species of the subgenus *Stigmatopteris* was known only from the original collection (*Wright* 1053), from some part of eastern Cuba. No. 10486 is viviparous in the axils of most of the pinnae, bearing young plants with leaves 1 to 2.5 cm. long.

Dennstedtia globulifera (Poir.) Hieron. Bot. Jahrb. Engler **34:** 455. 1904.

Loma del Gato and vicinity, Cobre Range, Sierra Maestra, at 1,000 to 1,100 meters elevation (*Léon, Clement & Roca* 10177).

New to Cuba; originally described from Hispaniola. The history and relationship of this species will be discussed shortly in another connection.

HYMENOPHYLLACEAE

Hymenophyllum lineare Swartz.

Pico Turquino; on tree trunk (11116).

The only undoubted Cuban specimen of this species seen by the writer, though it has previously been ascribed to the island. Described originally from Jamaica, where it grows commonly in large mats on tree trunks of the upper forested slopes of the Blue Mountains, at 1,600 to 2,225 meters altitude. On the continent *H. lineare* is reported from Mexico to Brazil and Peru, but the name is very loosely used for several species of this group, which needs critical revision. The Cuban and Jamaican plants are identical.

LYCOPODIACEAE

Lycopodium montanum Underw. & Lloyd, Bull. Torrey Club **33:** 107. 1906.

Turquino region; terrestrial (11099).

Known previously only from the summit of Blue Mountain Peak, Jamaica, altitude 2,225 meters.

Lycopodium serratum Thunb.

Pico Turquino, in woods; terrestrial (11161).

A widely distributed Old World species known in America, hitherto, only from Mexico, whence it was described as *L. sargassifolium* Liebm.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY

157TH MEETING

The 157th meeting was held at the Cosmos Club, February 7, 1922. President SAFFORD was in the chair and 86 members and guests were present. Señor CARLOS A. VALLEJO, of the Argentine Embassy, was elected a member.

Dr. D. N. SHOEMAKER spoke of the death of Dr. WALTER VAN FLEET, formerly a member of the Botanical Society, and gave a résumé of his life and work. Dr. Van Fleet was born at Piermont, N. Y., June 18, 1857, and died at Miami, Florida, January 26, 1922. He was educated in medicine, and kept up his medical practice in Pennsylvania until 1893. From that time on his interests were largely in horticulture, particularly in the development and improvement by hybridization of hardy roses and gladioli, as well as of cannas, strawberries, and many other cultivated plants.

A. S. HITCHCOCK: *Botanical and agricultural notes from the Orient* (illustrated).

Dr. Hitchcock left San Francisco May 3 for Manila, stopping 6 days in Honolulu and arriving at his destination June 2. One month was spent on the island of Luzon, mostly at Manila, but a trip was also made to Los Baños, the seat of the Agricultural College, and Baguio in the mountains of the northern part of the island. The month of July was spent in Japan at Yokohama, Tokyo, Nikko, Kyoto, Lake Hakone and Mt. Fuji. From a botanical standpoint Mt. Fuji was disappointing.

During August Dr. Hitchcock visited Nanking in China, making his headquarters at the University of Nanking, and Kuling, a mountain resort much frequented by the missionaries of central China. About the first of September he went to Canton staying at the Canton Christian College. He made trips from here to Yingtak and Shiuchow on the North River, to Lohfau mountain northeast of Canton, to Whampoa, a place visited by the Wilkes Expedition, and to Macao, a Portuguese possession and the first locality occupied by Europeans in southeast Asia. Collections were also made at Hong Kong, the gateway to this part of China.

One of the most impressive things in Chinese agriculture was the extent to which the valleys were cultivated in the most intensive manner, while the hills or lands just above and adjoining the valleys which grow an abundance of grass, had no stock grazing upon them, partly on account of fear of bandits. This grass, however, did serve the purpose of fuel for cooking.

An excursion of about 5 weeks was made to Indo-China and the island of Hainan. French Indo-China was entered at Haiphong in Tonkin. Dr. Hitchcock went by rail to Hanoi and Vinh and by autobus to Hue, the capital of Annam. Here he made collections of grasses chiefly for the purpose of interpreting the work of Loureiro, a Portuguese botanist who lived here and in 1790 published a flora of Indo-China. After going to Tourane on the coast he returned to Haiphong and sailed for Hainan. This large island lies in the tropics off the south coast of China and is seldom visited and little known. About ten days were spent here mostly in making a trip to Kachek and the foothills of the central mountains. After returning to Canton he went to

Manila and sailed on an army transport November 15 for home, arriving in Washington the day before Christmas. Large collections of grasses were made in the countries visited as the season was favorable for this purpose.

Mr. G. N. COLLINS spoke on the Toronto Meeting of the American Association for the Advancement of Science, specially dealing with the papers on Genetics. These were about evenly divided between the botanists and zoologists. The leading number of papers concerned *Drosophila*, while the papers on maize ran second in number.

Dr. G. R. LYMAN spoke of the meeting of the Pathologists at the Toronto Meeting, and of the plan to coordinate the various biological scientists into one association similar to that of the Engineers Society and the Medical Society.

ROY G. PIERCE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The educational courses at the Bureau of Standards this winter include: Harmonic Series Applied to Physical Problems, D. R. HARPER, 3D; Advanced Organic Chemistry, L. L. STEELE; Physical Metallurgy, H. S. RAWDON.

JOHN L. BAER, acting curator of American Archeology, National Museum, during the past few months, is in Pennsylvania, continuing his study of aboriginal quarry sites in the Shenandoah Valley.

Dr. ALEXANDER GRAHAM BELL, a resident member of the ACADEMY, died at his summer home in Nova Scotia on August 2, 1922, in his seventy-sixth year. Dr. Bell was born at Edinburgh, Scotland, on March 3, 1847. His invention of the telephone stands as his most notable scientific achievement, but he carried on research in various subjects, as for example, animal breeding, relief of deafness, applications of electricity, etc. He was a member of the ACADEMY, the Anthropological, Historical, and Philosophical Societies of Washington, and the Institute of Electrical Engineers.

HENRY B. COLLINS, JR., of Louisiana, a member of the 1922 National Geographic Society expedition to Pueblo Bonito, will spend the next few months in Washington studying the collections of the expedition.

MAYO D. HERSEY, formerly of the Bureau of Standards, and until recently associate professor of properties of matter in the department of physics, Massachusetts Institute of Technology, has resigned to take a position as physicist in charge of the physical laboratory of the U. S. Bureau of Mines at Pittsburgh, Pa.

NEIL M. JUDD, curator of American Archeology at the National Museum, returned to Washington September 28, following completion of the second season's explorations at Pueblo Bonito, under the auspices of the National Geographic Society. About forty secular rooms and five kivas were excavated during the summer and, in addition, considerable attention was devoted to study of the possible geophysical conditions which prevailed in Chaco Canyon at the time the great ruin was occupied.

Dr. SAMUEL W. STRATTON, director of the U. S. Bureau of Standards since its foundation in 1901, has resigned to become president of the Massachusetts Institute of Technology.

Dr. F. E. WRIGHT of the Geophysical Laboratory, Carnegie Institution of Washington, has returned after a year's absence in South Africa, where he has been engaged in geological and petrological investigations in company with Messrs. DALY, PALACHE, and MOLENGRAAF.

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GEOLOGY.—*Geology of a vein occurrence of rutile-ilmenite in a new locality.*[1] THOMAS L. WATSON, University of Virginia.

INTRODUCTION

In each of the several known world areas of commercial rutile, the mineral occurs as a primary constituent of some type of igneous rock, formed either as a product of crystallization from a molten magma or as the result of pneumatolysis. As a primary mineral formed under igneous conditions, rutile is a high temperature product, but probably not in all cases necessarily accompanied by high pressure. Accurate measurements by the Bureau of Standards, Washington, D. C., on carefully prepared specimens of rutile separated from the igneous rocks, syenite and nelsonite, of Nelson County, Virginia, gave 1690° C. (syenite) and 1700° C. (nelsonite).[2]

The occurrence of primary coarse rutile in veins and pegmatites is well known but not common. The two occurrences are closely related genetically, and in each, rutile has developed as a primary mineral under conditions of high temperature.

Of the vein occurrences of primary rutile, the mineralogic types, rutile-bearing apatite veins, with or without scapolite, and rutile-bearing quartz veins, with or without ilmenite, seem well established. Others are known, especially some metalliferous veins, in which rutile occurs as a minor constituent.

Representatives of the apatite vein type in Norway and Sweden have been described by Vogt[3] and are regarded by him to be of pneumatolytic character. In this type rutile is associated with the titanium minerals, ilmenite and titanite. Important rutile-bearing apatite bodies with or without ilmenite and known as the rutile variety of the igneous rock nelsonite occur in Nelson County, Virginia. These have been

[1] Received October 19, 1922.

[2] WATSON, THOMAS L. and TABER, S. Va. Geol. Survey Bull. **111-A**: 154. 1913.

[3] VOGT, J. H. L. *Genesis of Ore Deposits.* Trans. Amer. Inst. Min. Engrs., 646. 1901.

described by Watson and Taber,[4] who regard them as igneous dikes and not true veins.

The rutile-bearing quartz vein type, with or without ilmenite, is represented in the Piedmont Plateau province of the southern Appalachians, especially Virginia, where several occurrences are known. The known occurrences of this type of vein are characterized by the absence of all minerals except quartz and rutile and, in some instances, ilmenite. The purpose of this paper is to describe one of the more important occurrences of this type.

The older gneisses and schists of the Piedmont province of the southeastern Atlantic States have been freely injected in places by granite pegmatites and quartz veins, which both conform with and cut across the structure of the rocks. All gradations between typical granite pegmatites, with or without rarer minerals, and quartz veins, with or without other minerals, exist and can be traced. Black tourmaline is a frequent mineral in many of the quartz veins of the Virginia Piedmont province, but so far as the writer is aware it does not occur in the rutile-bearing type of quartz vein.

The pegmatite occurrence of rutile is likewise represented in the old gneiss-schist complex of the Virginia Piedmont Plateau province. One of the most important of these from the standpoint of probable commercial rutile is an area[5] in Goochland and Hanover counties, Virginia, near but within the eastern border of the Piedmont province. Here granite-gneisses are injected by granite pegmatites which conform as a rule, with the gneiss structure. Some of these carry rutile as a primary constituent in grains and masses of many pounds in weight. The rutile is frequently intergrown with ilmenite, but there is a singular absence of other minerals save the common rock-making silicates of granite pegmatites. Unlike the rutile-ilmenite intergrowths of the Franklin County, Virginia, quartz vein described below there is general absence of crystal form in the titanium minerals occurring in the pegmatites of Goochland and Hanover counties.

Recently rutile has been noted by the writer in one of the extensively worked pegmatites of the Amelia County, Virginia, area, so well known to mineralogists for the large number of rarer minerals found in them. Part of a prismatic crystal of rutile weighing 1 pound

[4] WATSON, THOMAS L. and TABER, S. Va. Geol. Survey Bull. III-A: 100–155. 1913.

[5] WATSON, THOMAS L. and TABER, S. Va. Geol. Survey Bull. III-A: 248–261. 1913. HESS, FRANK L. Mining World 33: 305–307. 1910.

was obtained by the writer during a recent visit to the area. No published record mentions rutile among the rarer minerals found in the pegmatites of this area.

Finally the pegmatite body described by Hess[6] at Baringer Hill, Llano County, Texas, carries rutile and is of especial interest on account of the association of minerals of the rare earth metals.

GEOLOGY OF THE VEIN AREA

The rutile-bearing quartz vein described in this paper is located in Franklin County, Virginia, 15 miles in a direct line southeast of Roanoke City and about 1 mile west of Teels Mill, near the entrance of Indian Creek into Roanoke River. It is crossed by the Roanoke-Franklin highway and is less than a mile southwest of Roanoke River. (See Roanoke, Virginia, topographic sheet, U. S. Geol. Survey.)

The vein occurs about 8 miles east of the main Blue Ridge in the pre-Cambrian schists of the western part of the Piedmont Plateau province. The surface of the area is one of moderately strong relief with an average elevation above sea level of between 900 and 1,000 feet. The rocks are deeply weathered, yet outcrops of fairly fresh and hard rock are common. Where crossed by the highway the vein has an elevation of 1,000 feet above sea level.

The vein is inclosed in dark gray, mica schists, composed chiefly of biotite, but variations in mineral composition are frequent. The structure (schistosity) of the schists strikes N. 50–60° E. and dips 80–85° S.E. Veins and thin stringers of white granular quartz similar to that of the rutile-bearing vein, but characterized by the absence of all minerals save quartz, are fairly numerous. They usually lie in the foliation planes of the schists and hence are comformable with the structure. Likewise occasional thinly schistose granite pegmatites not exceeding 3 feet in width, also occur in the schists conformable with the structure, but no indication of rutile was noted in them.

The schist weathers to a red clay soil through which are scattered leached yellow folia of biotite. Also loose fragments of white quartz derived from the quartz veins by weathering are thickly strewn over the surface in many places.

The vein outcrops on the north side of the road, on the Maxey place, as a low reef-like form traced for a distance of nearly 100 feet. Loose fragments (float) of the vein rock, however, can be traced

[6] HESS, FRANK L. U. S. Geol. Survey Bull. 340: 287–294. 1908.

beyond the outcrop for some distance to the northeast. Apparently the vein does not outcrop on the southwest side of the road, but quartz-rutile-ilmenite fragments are scattered over the surface for a short distance. Like the numerous quartz veins within the area the rutile-bearing vein apparently conforms with the structure of the inclosing schists, since it has a strike of N. 60° E. and dips 80–85° S.E. It will not exceed 50 feet in width.

The vein was prospected for rutile about 10 years ago with the reported result that considerable rutile was obtained, but nothing could be learned of its disposition. Development work was confined to the outcrop portion of the vein. It comprised a cut 60 feet long by an average of 5 feet deep opened in the vein. The cut extended from the road in a N. 60° E. direction (strike of the vein), and southwestward under the road for an additional distance of 30 feet. On the north edge of the road a shaft was sunk in the vein from the bottom of the cut for a depth of 30 feet. Most of the vein, so far as the development work discloses, is entirely barren, neither rutile nor ilmenite having been observed by the writer in its outcrop portion. The rutile obtained was derived chiefly from the shaft and to a less extent from that part of the open cut near the shaft.

The surface in the vicinity of the shaft, especially along the road side, is reported to have been thickly covered with fragments of quartz containing rutile crystals and of loose crystals of rutile free from quartz, but most of them have been taken away.

Small crystals of rutile and fragments of vein quartz with rutile were found on the J. S. Oyler place about 1 mile northwest of the rutile-bearing quartz vein on the Maxey place. Although no outcrop of a vein was noted in this locality, the surface indications undoubtedly suggest the occurrence of a rutile-bearing quartz vein of similar character to the one on the Maxey place.

MINERALOGY OF THE VEIN

The mineralogy of the vein is very simple. It is composed almost throughout of white vitreous quartz with, locally, rutile and ilmenite, which are the only other minerals observed. It is entirely massive and without evidence of mashing.

Quartz.—In thin sections under the microscope the quartz forms a mosaic of interlocking angular grains that are colorless and transparent, remarkably free from inclusions, and of exceptional purity. The

grains frequently show shadow extinction, but less often is there evidence of peripheral shattering or granulation.

Rutile.—The rutile is developed in elongated prismatic crystals of dark red-brown color up to $6^1/_2$ cm. ($2^9/_{16}$ inches) long and 1 cm. ($^9/_{16}$ inch) broad. The prism faces are usually vertically striated and in case of the larger ones are deeply furrowed. Terminal crystal faces are absent and twin crystals are rare. The rutile is locally distributed through the quartz matrix in clusters of prismatic crystals, and as scattered single crystals. Thin films or wedges of quartz sometimes part crystals for more than half their length. When the rutile crystals are broken from the matrix, the quartz surfaces are smooth, almost polished, and preserve completely the angles and striations of the rutile prism faces. The crystals are usually straight but curved ones sometimes occur.

In thin sections under the microscope the rutile is brownish yellow and without noticeable pleochroism. Cleavage is usually well developed but twinning is rare. Much of the rutile appears to be fresh, but some of it shows clouded surfaces indicating slight alteration. The rutile is partly intergrown with and partly altered to ilmenite, relationships which are discussed below. A chemical analysis of the rutile is given in column I of Table I.

Ilmenite.—This mineral exhibits no unusual microscopic characters. Occasional inclusions of quartz occur, but those of rutile are more frequent. Like the rutile it is usually fresh, but much of it shows partial alteration, chiefly about the boarders and along cleavage and fracture directions, probably to leucoxene. The most interesting feature of the ilmenite is its intergowth relation to rutile.

Microscopic study of thin sections shows that the two minerals rarely occur as separate individuals, but are usually intergrown with the characteristic prismatic habit of rutile. This relationship has frequently been observed by the writer in formless grains and masses of rutile, but rarely to such a degree in perfectly formed prismatic crustals of rutile. It is well brought out chemically in the analysis given in column II of Table I. The analysis was made on what was assumed, after careful examination to be a single individual of ilmenite, but on recasting the analysis in the usual way, it is clear that the specimen was composed of a mechanical mixture of rutile and ilmenite, with the former predominating.

Rutile-ilmenite relationships.—Microscopic study of thin sections

shows the rutile-ilmenite relations referred to above to be (1) definite intergrowths of the two minerals, and (2) alteration of rutile to ilmenite, all the important stages in the process being traced under the microscope. That the individual crystals in most instances are composed of a mixture of the two minerals is also evident megascopically, but without the microscope it is not possible to distinguish between ilmenite that is primary and that which is secondary.

Much of the ilmenite is undoubtedly secondary, the early stages in the alteration of the rutile being particularly well-marked under the microscope. These are shown principally in irregular dark gray nearly black patches and areas of variable size, composed of exceedingly fine granules of ilmenite, not connected apparently with lines of fracture or parting; and in similar irregular areas, directly connected with both fracture and parting (cleavage) planes, which gradually fade into the unaltered rutile. In each case the boundaries are gradational and lack sharpness of definition. Some ilmenite is developed in the rutile in reasonably closely spaced parallel line-like bodies having sharp definition and strongly suggestive of primary origin, but they may possibly be secondary.

A part of the ilmenite on the other hand is definitely primary, the two minerals, rutile and ilmenite, being molded against each other in sharp and distinct contacts, and each is inclosed in the other as in simultaneous crystallization. In some thin sections, the boundaries are more angular and irregular and are marked by reentrances and tiny stringers of ilmenite penetrating the rutile. In such cases these relations may cast doubt on the primary character of the ilmenite, but the irregular angular boundaries of the rutile-ilmenite are no more emphasized than are the boundaries between rutile and quartz in the same thin sections.

Some of the ilmenite has undergone partial alteration about the borders and along fractures to a fine-granular grayish substance probably leucoxene. Such peripheral alteration of the ilmenite is shown whether in contact with rutile or not. Distributed through this alteration product at times are very minute black granules which may represent residual ilmenite, although their identity is uncertain. The alteration in such cases makes it uncertain as to whether the ilmenite was originally primary or secondary, but the writer is rather inclined to regard much of it as having been originally primary and subsequently altered.

Bearing of rutile-ilmenite intergrowths on composition of rutile.—This subject is discussed elsewhere by the writer[7] and is only briefly touched on here. The intergrowth relations of the two titanium minerals described above have their analogy in the titaniferous magnetites which have been shown by others to be a mechanical mixture of ilmenite in the host magnetite.

All modern analyses of rutile show the presence of ferrous oxide in variable amounts. The writer suggests that probably the source of this constituent is from ilmenite mechanically mixed with rutile and not from a supposed isomorphous mixture of ferroustitanate ($Fe(TiO_3)$) and titanyl titanate $(TiO)(TiO_3)$, as has been advanced by some.[8] This explanation certainly seems applicable to the rutile of the Franklin County, Virginia, vein. Many supposed cases of isomorphism among sulphide minerals have been shown by modern critical study to represent mechanical mixtures.[9] The writer is convinced that this relationship holds among opaque oxides.

CHEMICAL COMPOSITION OF THE RUTILE-ILMENITE

Chemical analyses of the rutile and rutile-ilmenite from the Franklin County, Virginia, rutile-bearing quartz vein are given in Table I below.

TABLE I.—ANALYSES OF RUTILE AND RUTILE-ILMENITE, FRANKLIN COUNTY, VIRGINIA

	I	II
TiO_2	97.30	80.85
SiO_2	.12	.06
Cr_2O_3	.05	.03
V_2O_3	.26	.17
FeO	2.21	18.81
MnO	.09	.14
H_2O	.10	.04
	100.13	100.10

I. Rutile, Franklin County, Virginia. William M. Thornton, Jr., analyst.

II. Rutile-ilmenite, Franklin County, Virginia. Dorothy Getz, analyst.

The possible effect of the presence of Cr_2O_3 and V_2O_3 in rutile, as shown in all recent accurate analyses, has been discussed by the

[7] WATSON, THOMAS L. *Rutile-ilmenite intergrowths.* Amer. Mineralogist. 1922. (In press.)

[8] SCHALLER, W. T. U. S. Geol. Survey Bull. 509: 9–39. 1912, and references.

[9] WHERRY, E. T. This JOURNAL 10: 488. 1920. FOSHAG, W. F. Am. J. Sci. 1921.

writer in an earlier number of this Journal.[10] Recasting the two analyses above by allotting FeO to TiO_2 to form ilmenite ($FeO.TiO_2$) the mineral composition in terms of rutile and ilmenite is:

	I	II
Rutile	94.80	59.92
Ilmenite	4.71	39.67
Rest	.62	.44
	100.13	100.03

The analysis in column II clearly shows a mixture of rutile and ilmenite, in which rutile is in largest amount. Although a thin section of this particular specimen was not examined, it is not improbable that some of the ilmenite may have been secondary.

BOTANY.—*The genus* Culcita.[1] WILLIAM R. MAXON, National Museum.

The tribe Dicksonieae, one of the three groups of Cyatheaceae or tree ferns, is usually regarded as consisting of three genera: *Dicksonia*, *Cibotium*, and *Balantium*, all represented in both hemispheres. The distinctions between *Dicksonia* and *Cibotium* are fairly pronounced, and both names are currently applied in their proper sense. *Balantium*, though showing indusium characters similar to those of *Dicksonia*, is habitually very different from either, and its recognition as a valid genus is general. The name *Balantium*, however, is technically a synonym of *Dicksonia* and must be supplanted by *Culcita*, as shown below. The distinctive characters of the genera of Dicksonieae were stated briefly by the writer a few years ago in a popular article on the tree ferns of North America[2] and the name *Culcita* was there employed in the present sense, without, however, a statement of the reasons for substituting it for *Balantium*.

The genus *Dicksonia* was described by L'Héritier in 1788 [3] with two species: *D. arborescens*, from St. Helena, and *D. culcita*, from San Miguel, one of the Azores, both being proposed as new. The former is an arborescent plant and, except for its temporary reference to *Balantium* by Hooker in 1838, has been consistently retained as the

[10] WATSON, THOMAS L. This JOURNAL 2: 431–434. 1912.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received October 9, 1922.

[2] Report Smiths. Inst. 1911: 463–491. *pl. 1–15*. 1912.

[3] Sert. Angl. 30. 1788.

typical member of a group of species now numbering more than a score, under the generic name *Dicksonia*. The second species, *D. culcita*, became later the type of *Culcita* Presl.

The genus *Cibotium* of Kaulfuss, though sometimes credited to his *Enumeratio Filicum* (1824), was actually published four years earlier in a little known pharmaceutical journal.[4] The type and only species mentioned at the original place of publication is *C. chamissoi*, of the Hawaiian Islands. There are about ten recognized species, most if not all of them treelike. The North American members of the genus have been discussed by the writer.[5]

The genus *Balantium* Kaulf., was proposed in 1824,[6] with two species: *B. auricomum* Kaulf. (p. 228) and *B. culcita* (L'Hérit.) Kaulf. (p. 229). Kaulfuss' redescription of *B. culcita* is only two lines long and omits all mention of the sori; but of *B. auricomum* there is a long and detailed description (agreeing very closely with the generic diagnosis) and a figure, which indicate clearly the importance of this species in the describer's mind and seem to justify the acceptance of this, rather than *B. culcita*, as the generic type. There is every reason to suppose that the material of *B. auricomum* supplied the major data for his generic description. *Balantium*, thus typified by *B. auricomum* (= *arborescens*), becomes a synonym of *Dicksonia*, founded on the same species. Since in recent years *Balantium* has been tacitly regarded as typified by *B. culcita*, the genus *Balantium* of authors must receive another name. Fortunately, *Culcita* is available.

The genus *Culcita* Presl dates from 1836,[7] and is founded on a single species, *Culcita macrocarpa* Presl, a change of name for *Dicksonia culcita* L'Hérit. and *Balantium culcita* Kaulf. It is thus exactly the equivalent of the genus *Balantium* of recent writers.[8]

The species of *Culcita* are as follows:

1. **Culcita macrocarpa** Presl, Tent. Pter. 135. *pl. 5, f. 5*. 1836.
   Dicksonia culcita L'Hérit. Sert. Angl. 31. 1788.
   Balantium culcita Kaulf. Enum. Fil. 229. 1824.

[4] Berl. Jahrb. Pharm. **21**: 53. 1820.

[5] Contr. U. S. Nat. Herb. **16**: 54–58. *pl. 30–32*. 1912.

[6] Enum. Fil. 228. 1824.

[7] Tent. Pter. 135. *pl. 5, f. 5*. 1836.

[8] It is interesting to note that Presl applies the name *Balantium* in the sense of *Dicksonia* with the exception of a single species, and further that he takes up the name *Dicksonia* for the genus of Polypodiaceae that we now call *Dennstedtia*, omitting therefrom both of the species originally described under *Dicksonia* by L'Héritier!

The generic type; known from Madeira, Teneriffe, and several of the Azores; originally described from San Miguel. The very large sori at once distinguish this species, of which the following specimens are at hand:

MADEIRA: San Vicente, June 21, 1850, *Lowe* 31. Without special locality *Mandon* 300; *Mason* in 1857.

AZORES: San Miguel, *Trelease* 1143. Pico, *C. S. Brown* 317.

2. **Culcita coniifolia** (Hook.) Maxon, Report Smiths. Inst. **1911:** 488. *pl. 13, f. c.* 1912.

Dicksonia coniifolia Hook. Sp. Fil. **1:** 70. *pl. 24. A.* 1844.
Dicksonia martiana Klotzsch; Hook. Sp. Fil. **1:** 70. *pl. 24. B.* 1844.
Balantium martianum Fée, Vasc. Crypt. Brés. **1:** 155. 1869.
Culcita schlimensis Fée, Mém. Foug. **10:** 47. *pl. 36, f. 3.* 1865.
Balantium coniifolium J. Sm. Hist. Fil. 258. 1875.

Variable in several characters, but perhaps no more so than to be expected in a plant occupying so wide an area. Its nearest ally is *C. macrocarpa.* Hooker's type was from Caracas (*Linden* 538). The following specimens are in the National Herbarium:

JAMAICA: John Crow Peak, alt. 1,650 to 1,800 meters, *Harris* 7336; *Underwood* 3258; *Maxon* 1333, 1333a; Blue Mountains, alt. 1,800 meters, *Hart* 132.

CUBA: Near summit of Pico Turquino, Sierra Maestra, *Léon* 11155.

COSTA RICA: San Cristóbal, *Werckle.* San Jerónimo, alt. 1,500 meters, *Werckle* (Jiménez, no. 578). Without locality, *Brade* 142.

PANAMA: Humid forest between Alto de las Palmas and top of Cerro de la Horqueta, Chiriquí, alt. 2,100 to 2,268 meters, *Maxon* 5459, 5459a. Cordillera above "Camp I," Holcomb's Trail, 10 miles above El Boquete, Chiriquí, alt. 2,100 to 2,150 meters, *Killip* 5326, 5328.

COLOMBIA: Medellín, *Bro. Henri-Stanislas* 1714. Murillo, Tolima, alt. 2,100 to 2,500 meters, *Pennell* 3181. Camino de Gachetá, *Bro. Ariste-Joseph* A483. Guasca, *Bro. Ariste-Joseph* A217. Without locality, *Bro. Ariste-Joseph* 198; *Triana* 179.

BRAZIL: Serra do Itatiaya, *Dusén* 170; same locality, alt. 2,000 meters, *Rose & Russell* 20490.

Reported also from Hispaniola, Mexico, and Ecuador.

3. **Culcita javanica** (Blume) Maxon.

Dicksonia javanica Blume, Enum. Pl. Jav. 240. 1828.
Dennstedtia javanica Christ, Bull. Herb. Boiss. II. **4:** 617. 1904.
Balantium javanicum Copel. Phil. Journ. Sci. Bot. **4:** 62. 1909.

Described from Java and attributed only to that island. Not seen by the writer. Listed by Christensen as valid, and so regarded by recent writers.

4. **Culcita formosae** (Christ) Maxon.

Dennstedtia formosae Christ, Bull. Herb. Boiss. II. **4:** 617. 1904.
Balantium formosanum Christ, Geogr. Farne 155. 1910.

Founded upon specimens collected on Formosa by Faurie (no. 676). Said to be a close ally of *C. javanica*, but listed by Christensen as valid. No material has been seen.

5. **Culcita copelandi** (Christ) Maxon.

Dicksonia copelandi Christ, Phil. Journ. Sci. Bot. **2**: 183. 1907.
Balantium copelandi Christ; Copeland, Phil. Journ. Sci. Bot. **3**: 301. 1908; **4**: 62. *pl. 19*. 1909.

A very distinct species, separated by Christ from *C. straminea;* apparently confined to the Philippines. The true indusium is somewhat membranous, erose-dentate, and provided with occasional cilia. In these respects and in its pronounced hairy covering the plant shows less alliance with *C. straminea* than with *C. dubia* and the new species here described as *C. blepharodes*. The following specimens are in the National Herbarium:

LUZON: Vicinity of Baguio, Province of Benguet, *Elmer* 6025 (co-type), 9000; *Topping* 196, 241; *Bartsch* 241; *Loher* 1304. Province of Abra, *Ramos* 7158. Mount Tonglon, *Loher* 965.

NEGROS: Dumaguete (Cuernos Mountains), Province of Negros Oriental, *Elmer* 9694, 9899, 10394.

6. **Culcita straminea** (Labill.) Maxon.

Dicksonia straminea Labill. Sert. Austr. Cal. 7. *pl. 10*. 1824.
Dicksonia torreyana Brack. in Wilkes, U. S. Expl. Exped. **16**: 278. *pl. 38, f. 2*. 1854.
Dennstedtia straminea J. Sm. Hist. Fil. 265. 1875.
Balantium stramineum Diels in Engl. & Prantl, Pflanzenfam. 1^4: 119. 1899. Not *Sitolobium stramineum* Brack. 1854.

Described and figured by La Billardière on specimens from New Caledonia; attributed by Christensen to Polynesia generally. The following specimens are at hand.:

NEW CALEDONIA: Koghis, alt. 250 meters, *Franc* 477. Yahoué, alt. 250 meters, *Franc* (*Rosenstock*, no. 63).

FIJI ISLANDS: Sandalwood Bay, *Wilkes Exped.* (type of *Dicksonia torreyana* Brack., 3 sheets). Without special locality, *Prince* in 1898.

SAMOAN ISLANDS: Savaii, *Reinecke* 143a (2 sheets, both labeled "*Davallia moluccana* Bl. var. *amboynensis* Hook."). Upolu, *Betsche* 119 (as *Dicksonia dubia* Gaud.); *Reinecke* 97 (2 sheets, both labeled "*Davallia moluccana* Bl., normale Form."); *Reinecke* 190 (labeled "*Davallia dubia* R. Br."). Tutuila, just below top of Matefao, *Setchell* 389. Island not indicated, *Powell* 117 (as *Dicksonia straminea*).

These plants agree well among themselves and represent a single species that must be regarded as referable to *Culcita,* notwithstanding their arborescent habit; the trunk is described by Brackenridge as "8 to 10 feet high, its surface rough, owing to the base of the old stipes remaining attached to it," in this character resembling *Dicksonia*.

The sori, though very small in comparison with those of *C. macrocarpa* and *C. coniifolia,* are similar in structure; the receptacle is elongate transversely; the outer valve of the "indusium" is formed of a slightly modified, but deeply saccate, recurved lobule of the leaf margin, with pale thin borders; the inner lip, or true indusium, is similar in form to the outer, being vaulted,

ample, subcoriaceous, and subentire, and closes against it, as if hinged on the transverse receptacle.

In these particulars the resemblance of *Culcita straminea* to the Australian plant described as *Davallia dubia* R. Br. is slight, yet the two have been greatly confused. The original description of *Davallia dubia* reads as follows: "Frondibus supradecompositis, foliolis 2-3-pinnatis pubescentibus, pinnulis lineari-lanceolatis incisis, involucris subrotundis fimbriatis subaxillaribus lobulo saepe reflexo semitectis. (J. D.) *v. v.*" The specimens were from Port Jackson (New South Wales) and Tasmania. The numerous Australian specimens at hand (cited hereafter) agree perfectly with Brown's description in having the marginal lobule opposite to the sorus often reflexed and sometimes partially protecting the sori; but the sorus is relatively distant from the margin, the marginal lobule is not at all modified and is never saccate, and the true indusium is membranous and conspicuously dentate-ciliate, is early thrust back against the leaf surface, and in form, structure, texture, and position is so unlike the marginal lobule that it can hardly be regarded as forming any part of a "double" indusium. In these respects *C. dubia* differs so definitely from *Culcita* proper that it ought at least to be regarded as the type of a new subgenus. The details of structure are shown fairly well in Hooker's plate 24, figure C.[9]

The Fiji plant listed by Brackenridge in 1854 as *Sitolobium stramineum* is not *Culcita straminea*, but a new species very closely allied to the *Davallia dubia* of Robert Brown. It is described below.

Not all of the Reinecke plants from Samoa distributed as *Davallia moluccana* Blume or one of its varieties pertain to *C. straminea*. The following numbers, as represented in the National Herbarium, belong to *Saccoloma moluccanum* (Blume) Mett., regarding that species in its usual widely collective sense: *Reinecke* 71 and 97a, 4 sheets, from Upolu; *Reinecke* 143, from Savaii.

7. **Culcita dubia** (R. Br.) Maxon.

Davallia dubia R. Br. Prodr. Fl. Nov. Holl. 157. 1810.
Dicksonia dubia Gaud. in Freyc. Voy. Bot. 367. 1827.
? *Balantium brownianum* Presl, Tent. Pter. 134. *pl. 5, f. 4.* 1836.
Sitolobium dubium Brack. in Wilkes, U. S. Expl. Exped. **16**: 273. 1854.

As noted under the last preceding species *Davallia dubia* was founded on material from New South Wales and Tasmania. Luerssen[10] cites four collections from the Fiji group as *Dicksonia dubia*, but they doubtless pertain to the next species, *C. blepharodes*. As represented in the National Herbarium *C. dubia* is confined to Australia, the specimens being as follows:

AUSTRALIA: Vicinity of Sidney, New South Wales, *Wright; Dämel* (ex herb. Bot. Mus. Hamburg); *Wilkes Exped.* (2 sheets, as *Sitolobium dubium*).

[9] Sp. Fil., vol. 1, 1844, as *Dicksonia dubia* (R. Br.) Gaud.

[10] Fil. Graeff. 233. 1871.

"Eastern coast," *Verreaux* 135 (as *Dicksonia davallioides*). Without special locality, *Verreaux* 290 (2 sheets, as *Davallia dubia*). Gippsland, Victoria, *F. von Müller*. Without special locality, *Schomburgk*.

The sorus characters of this species and of *C. straminea* have been discussed under the latter species. Since *C. blepharodes* is somewhat intermediate in sorus structure, *C. dubia* may best be regarded as the type merely of a new subgenus, **Calochlaena,** the name being chosen in allusion to the distinctive character of the delicate true indusium.

A good deal of doubt exists as to the proper reference of *Balantium brownianum*. This name was proposed in 1836 by Presl, who cited as synonyms *Davallia dubia* R. Br. and *Dicksonia fallax* Kaulf., and published an illustration (*pl. 5, f. 4*). The name *Davallia fallax* had been given by Kaulfuss to an Australian plant distributed by Sieber. Luerssen, who has examined this, refers it to *Dicksonia dubia;* but the highly conventional figure shows sori like those of *C. straminea*, as Hooker has remarked, and bearing very little likeness to those of *C. dubia*, whether or not it was drawn from Australian material. Brackenridge has pointed out the same discrepancy, and until the Sieber plant has been re-examined critically the correct disposition of *Balantium brownianum* must remain doubtful.

8. **Culcita blepharodes** Maxon, sp. nov.

Frond (incomplete) 1 meter long or more, the stipe about one-third as long as the blade, sulcate, ochraceous from a darker base; blade tripinnate, the pinnae subopposite, ascending, about 30 cm. long, 5 to 8 cm. broad, narrowly deltoid-oblong, the rachis firm, brownish-stramineous; pinnules distant, alternate to subopposite, oblique, deltoid-oblong, acuminate; segments 10 to 15 pairs, slightly oblique, linear or linear-oblong, cuneate at the inequilateral base, abruptly acuminate, distant, faintly connected along the ventral groove of the tertiary rachis, deeply lobed throughout; lobes of the larger segments 5 to 7 pairs, mostly with 2 lobules or crenations on the distal side, the apical one sterile and curved upward, the other broader and soriferous; sorus about 1 mm. in diameter; fertile lobule invariably concave, but not saccate; true indusium ample, delicately membranous, long-ciliate, born upon a narrowly oblong, transverse receptacle, early thrust backward against the leaf surface and exposing the numerous sporangia; paraphyses many, slender, brown; under surface of blade freely villous-hirsute, the hairs extending abundantly to the veins; upper surface slightly hirsute, glabrescent.

Type in the U. S. National Herbarium, no. 1,094,080, collected at "Lomo-Lomo" or "Somu-Somu," Fiji Islands, by the Wilkes Expedition (1838–42). There is a second, smaller specimen of the same collection.

This is the plant which Brackenridge, having mistakenly redescribed the *Dicksonia straminea* of La Billardière as a new species of *Dicksonia* (*D. torreyana* Brack.), listed as *Sitolobium stramineum*. He properly compares it with *Sitolobium dubium* Brack. (*Culcita dubia*) and notes several points of distinction.

Culcita blepharodes belongs to the subgenus *Calochlaena*, and is closely

allied only to *C. dubia*. From that it differs in having the receptacle nearer the margin, the marginal lobule regularly though not deeply concave (not recurved or reflexed, as in *C. dubia*) and approaching somewhat the "accessory indusium" form of typical *Culcita*, and the true indusium larger and more freely long-ciliate. The specimen selected as the type is very incomplete, and the measurements are thus not dependable. As noted previously this is doubtless the plant listed by Luerssen as *Dicksonia dubia* on Fiji specimens collected by Graeffe (nos. 151, 490) and *Dämel* (nos. 31, 32).

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY OF WASHINGTON

867TH MEETING

The 867th meeting was held in the Cosmos Club auditorium Saturday, May 20, 1922, with President CRITTENDEN in the chair and 42 persons present.

R. C. TOLMAN: *Some remarks on the Quantum Theory.* This paper was illustrated by charts and figures, and was discussed by Messrs. BEAL, C. A. BRIGGS, FAIRCHILD, FOOTE, HAWKESWORTH, MOHLER, PAWLING, SOSMAN, TUCKERMAN, WELLS and WHITE. This paper has been published in full in 1922, number of the Journal of the Optical Society.

The speaker first reviewed the steps by which the Classical Dynamics was led to expect that there would be an equipartition of energy between the different modes of vibration in the hohlraum. The modifications in the Classical Dynamics which are proposed by Quantum Theory to meet the contradiction between this prediction of the Classical Dynamics and the experimental facts were then discussed.

The equations given by Quantum Theory for the possible steady motions of simple oscillators and rotators and for the distribution of elements at thermodynamic equilibrium were then developed. It was shown how these equations account for the photoelectric effect, the inverse photoelectric effect, the relation between the frequenceis of absorbed and phosphorescent light, the energy distribution in the hohlraum, the Debye theory of the specific heat of solids, the theory of rotational specific heat of gases, the theory of the rotational spectra of gases, and the theory of the emission spectra of the elements.

The Quantum Theory was then criticised from the point of view of its arbitrariness, its conflict with the facts concerning the undulatory nature of light, its apparently unnecessary abandonment of the Classical Dynamics in solving the problem of the distribution of energy in the hohlraum and the unsatisfactoriness of its atomic model. A model which contains some features which it might be desirable to incorporate in the final model of the hydrogen atom was then exhibited.

W. R. GREGG, *Recording Secretary, Pro Tem.*

869TH MEETING

The 869th meeting was held in the Cosmos Club auditorium Saturday, October 7, 1922.

By invitation Mr. RAYMOND DAVIS presented a paper on "deciphering of charred paper records" which was illustrated by lantern slides. After the presentation of the paper the author answered numerous questions by Messrs. WHITE, CRITTENDEN, HEYL, and others.

Author's Abstract: The bureau of Standards was recently called upon to find a method for deciphering the written and printed matter contained on charred paper.

The charred papers submitted apparently had been subjected to heat in a closed vessel, such as a safe,—the paper having been converted into black sheets of carbon and not to ashes as would have been the case had they been burned in an open container.

With casual observation no traces of writing are visible, but under certain critical conditions of lighting very faint traces of markings can be seen. These traces are not sufficiently clear to permit deciphering.

In some preliminary trials made on paper charred for the purpose, conversion of the iron salts contained in the ink into colored salts was tried. These were unsuccessful.

It is known that the photographic plate, besides being sensitive to light, is also sensitive to certain gases and vapors. Some of these have the property of fogging or rendering developable such portions of the plate as are exposed to their actions. Certain other gases or vapors have the contrary property, that is, they partially or completely desensitize the plate.

For the first trial a sheet of the carbonized paper was placed between the two "fast" photographic plates and kept in the dark for two weeks. On development in the usual manner a very perfect copy of both the writing and the printing was obtained. It appears that the carbonized paper contains gases that fog the photographic plate. Where the ink is present, little or no effect takes place. Apparently the ink acts as a screen, hindering the escape of the gas.

It is interesting to note that the writing on both sides of the charred paper appears, that from the back being fainter than that from the face. Apparently the ink penetrates the paper sufficiently so that its residue reduces the amount of gas escaping from beneath.

No attempt was made to determine the nature of the active material contained in the charred paper. It is quite likely that it contains products similar to those obtained by the destructive distillation of wood.

Further tests showed that photographic plates of sensitiveness usually termed fast or medium are best adapted for this purpose. However, the sensitiveness to light is no definite indication of the sensitiveness to the charred paper. For example Seed 30 and Seed 26 X are of equal sensitiveness to the charred paper, the former is considerably faster to light than the latter. Very good copies can be obtained with either of these plates after a weeks time in contact with charred paper. Very slow plates such as "*Process*" are not suitable as exposure of 32 days shows only faint action. Photographic printing and enlarging papers are very insensitive to the charred paper.

Results obtained by the use of photographic films were very surprising, as shown by the two types of emulsions selected for the test, namely: Eastman "*Portrait Film*" and Eastman "*Super Speed Portrait Film.*"

The Portrait Film showed no effect in 32 days. The Super Speed Portrait showed very slight but interesting effect with a 16 day exposure and only a little better at 32 days. This was just the reverse of that with the plates,

the inked areas showing black on the films, whereas on the plates they showed clear. That is, with the films the ink is the active portion, the charred paper producing no fogging. It is also noted that the chemical fog of development is much lighter over the portions of the film covered by the charred paper as compared with the uncovered areas.

The results suggest that there are perhaps two different kinds of gases given off, one kind by the charred paper and another by the ink, both of which fog the photographic emulsion, but the one from the charred paper more rapidly.

It was found that a short washing of these films in distilled water, about five minutes, followed by thorough drying, gave results similar to those obtained with plates. Very good copies were obtained from washed film after 8 days contact with the charred paper.

Mr. R. W. G. WYCKOFF presented a paper entitled "Crystal structure of ammonium chloride and hydrazine hydrochloride," which was illustrated by diagrams. It was discussed by Messrs. HAWKSWORTH, TUCKERMAN, CRITTENDEN, and BROWN.

Author's Abstract: *The crystal structure of hydrazine dihydrochloride.* Using Laue photographic and spectrographic data and making use of the results of theory of space groups, the manner of arrangement of the atoms within the unit cube of a crystal of hydrazine hydrochloride, which contains four chemical molecules and is 7.89 A.U. on a side, has been determined. The corresponding space-group is T_h^6. The parameter v defining the positions of the chlorine atoms is found as 0.27+ and the most probable value of the nitrogen parameter is estimated as about 0.04. The distance between adjacent chlorine atoms thus is approximately 3.69 A.U.; between chlorine and nitrogen atoms about 3.14 A.U. It is pointed out that these results are markedly at variance with the hypothesis of constant atomic radii.

On the crystal structure of ammonium chloride.—It is shown that the Laue photographic data obtained from crystals of the low temperature form of ammonium chloride are in agreement with the powder data in assigning to it a structure containing one chemical molecule within the unit cube. The disagreement between the symmetry of the arrangement of the atoms of ammonium chloride and its described crystallographic symmetry is thus completely established. As a result it is pointed out that unless these crystallographic data are shown to be erroneous it will not be permissible to accept etch figure data and face development as definite indications of the symmetry of the arrangement of the atoms within a crystal.

Mr. W. W. COBLENTZ read a paper on "*Further measurements of stellar temperatures and planetary radiation,*" which was illustrated by lantern slides. It was discussed by Messrs. WHITE, PAWLING, and ABBOT.

Author's Abstract: During the past summer, through the generosity of the Lowell Observatory, Flagstaff, Arizona, who financed this research, a further opportunity was presented to continue the measurements of 1921 relating stellar temperatures and planetary radiation. Especial acknowledgement is due Dr. C. O. Lampland for kindly operating the telescope.

The speaker reported a verification of the estimate presented before this Society (The meeting of December 17, 1921) of the temperatures of 16 stars as determined from their spectral energy distribution which was obtained by means of a new spectral radiometer, consisting of a series of transmission screens and a vacuum thermocouple.

By means of these screens, which, either singly or in combination, had a uniformly high transmission over a fairly narrow region of the spectrum and terminating abruptly to complete opacity in the rest of the spectrum, it was possible to obtain for the first time the radiation intensity in the complete stellar spectrum as transmitted by our atmosphere.

The recent measurements of the spectrol radiation components, made principally on the sun, the temperature of which was used as a standard of comparison, verify the previous measurements of stellar temperatures, which range from 3000° K for red, class-M stars, to 12000° K for blue, class-B stars.

Planetary radiation.—The thermal radiation emitted from a planet as a result of warming by exposure to solar radiation, including heat which may be radiated by virtue of a possible high internal temperature of the planet itself, is essentially of long wave lengths 7μ to 12μ. Hence, by means of a 1 cm. cell of water, interposed in the path of total radiation emanating from the planet, this long wave-length radiation can be separated from the reflected solar radiation, and in this manner a measurement obtained of the energy reradiated. If there is planetary radiation then the water cell transmission will be less than that of direct solar radiation.

It was observed that the water cell transmission of the total radiation emanating from Jupiter is practically the same as that of the direct solar radiation. From this it appears that the outer atmosphere of Jupiter does not radiate appreciable long wave length infra-red energy as the result of warming by solar rays, and that the atmosphere is sufficiently thick and opaque to trap all the energy reradiated as the result of warming of its interior by solar radiation, or by internal heating, if the interior of Jupiter is still highly heated.

The radiometric measurements of Venus, Jupiter, and Saturn are in good agreement with similar measurements made at Mt. Hamilton, Calif., in 1914, showing a decidedly lower transmission of radiation through the water cell in the case of Venus and Saturn.

The intensity of the planetary radiation increases with decrease in the density of the surrounding atmosphere and (as interpreted from the water cell transmissions) in per cent of the total radiation emitted is as follows: Jupiter (0), Venus (5), Saturn (15), Mars (30), and the Moon (80).

The water cell transmission of the radiations from the Southern (50.6%) and northern (53.1%) hemispheres of Mars should be and are higher (*i.e.*, the planetary radiation is lower) than that of the radiations emanating from the equatorial (47.3%) region, owing to the depletion of the reradiated energy by the greater air mass. Moreover, the intensity of the planetary radiation from the northern hemisphere of Mars was found to be less than from the southern hemisphere. This is to be expected in view of the observed cloudiness over the northern hemisphere which is approaching the winter season and hence is at a lower superficial temperature.

The radiometric measurements of Mars are of especial interest in view of the question of the temperature of this planet.

The calculations of Lowell, based on the heat retained, give a mean temperature of 9° C. for the surface; while another calculation gives a temperature of 22° C. He points out that owing to cloudiness, only 60 per cent of the incident solar radiation is effective in warming the earth, while 99 per cent is effective in warming the surface of Mars.

In a recent discussion of climatic conditions on Mars, inferred from phenomena generally observed on the planet, Pickering estimates the mean annual temperature at 20° F. as compared with the mean annual temperature of the earth at 59° F. (15° C.). At night the Martian temperature is below 32° F. (0° C.) and at noon it is perhaps 60° to 70° F. (15° to 20° C.). These estimates are arrived at from the appearance and disappearance of snow and frost during the course of the Martian day, and from the fact that snow is never seen on the equator at Martian noon.

The radiometric measurements are in agreement with the calculation of Lowell and with the arguments recently set forth by Pickering, showing a considerable rise in temperature of the surface of Mars.

Probably the most convincing experimental observations of the range of temperature of the moon are those of Langley and Very, and later, those of Very. These measurements indicate inferred effective lunar temperatures ranging from 45° C. to over 100° C. The calculated value using recent data on the solar constant, indicates a lunar temperature of 82° C. When we consider that 30 per cent of the total radiation emanating from Mars is of planetary origin, as compared with 80% from the moon, and that all the evidence shows that the lunar surface becomes appreciably warmed, it appears that there is also a considerable temperature rise (10° to 25° C.) on the surface of Mars as calculated by Lowell. So whether or not we accept the view that vegetation can exist on Mars, the radiometric measurements confirm other meteorological data, showing that at Martian noon the snow is melted which could not happen if the temperature were —39° C., as some have calculated.

As for the views held by some of the possibility of vegetation growing on Mars, much depends upon whether we think of palm trees growing in our tropics, or the mosses and lichens which thrive on the apparently bare piles of volcanic cinders of Arizona and under our Arctic snows.

H. H. KIMBALL, *Recording Secretary*

ENTOMOLOGICAL SOCIETY

349TH MEETING

The 349th meeting of the Society was held May 4, 1922 in Room 43 of the New National Museum, with President GAHAN in the chair and 36 persons present.

Mr. GAHAN spoke briefly about the new Brazilian Entomological Society.

The first paper of the evening was *The operation of the Federal Insecticide Act*, by Dr. J. K. HAYWOOD. It was discussed by Dr. MCINDOO.

Messrs. HAYWOOD and MIDDLETON spoke of tree doctors injecting trees with fluids to kill insects.

Notes.—MR. BRIDWELL announced the discovery of a *Bruchophagus*, indistinguishable from *B. funebris*, from seeds of *Oxytropis lamberti* collected by L. WELD in Colorado. This is apparently the first record of this species breeding in legumes other than clover and alfalfa.

Dr. ALDRICH stated that Dr. C. H. T. TOWNSEND had completed his book on the muscoid flies. It has been sent to the United States for publication.

J. A. HYSLOP spoke as follows: "I have received a most interesting communication from Mr. C. W. CREEL, State Entomologist of Nevada, accompanying a vial containing a large number of Chrysomelid beetles. Mr Creel stated that the County Agent of Clark County sent in these specimens,

which were unknown to him, with a statement that they were doing very serious damage to all the vineyards in the Las Vegas Valley in southern Nevada. This is a desert region where they are growing Muscat grapes under irrigation. The beetles prove to be *Glyptoscelis squamulata* Crotch, a species which has been collected in southern California and Arizona on sage brush and the small desert sunflower *Balsamorhiza sagittata*.

"It is evidently a native desert insect which has turned its attention to the cultivated plant which has usurped its territory. The County Agent went on to say that the insects do their work at night, boring small holes into the buds just before the vines started to leaf out, and eating out the center of the bud."

350TH MEETING

The 350th meeting was held June 1, 1922, in Room 43 of the New National Museum, with President GAHAN in the chair and 57 members and guests present.

The first paper of the evening was an account by Dr. WM. M. MANN of his recent trip to South America on the Mulford Exploration, illustrated with lantern slides.

The balance of the evening was devoted to notes and exhibition of specimens.

Dr. MCINDOO asked where the silk was obtained which was used in the ants' nests. Dr. MANN said it was obtained from the larvae.

Mr. HYSLOP spoke of a nitidulid attacking strawberries in New York and Connecticut. He stated that about three years ago specimens of a small nitidulid were sent to the National Museum from Youngstown, N. Y., for determination. These proved to be the European *Heterostomus pulicarius* L., a species apparently of but little economic importance in Europe, where it is recorded as feeding on the pollen of Linaria. In 1920 Mr. H. NOTMAN described what Mr. SCHWARZ considers as this species under the name of *H. mordelloides*, from Schoharie, New York. In 1921, Mr. H. MORRISON collected specimens of this same beetle in Arnold Arboretum at Boston. In this number of the Bulletin is a report by Dr. E. P. FELT that this insect is seriously damaging strawberries in Columbia County, and is distributed over Saratoga, Albany, Niagara, and Schoharie Counties, New York. The damage is done by the adult beetles feeding at the base of young blossoms and producing "nubbins" or entirely destroying the fruit.

One of the most interesting developments of the month has been the determination as *Anomala orientalis* Water, of a beetle collected in Connecticut during the past two years. This is the *Anomala* which occasioned so much concern in Hawaii about ten years ago. The insect is a native of Japan and was probably introduced into Hawaii before 1908 in soil on the roots of imported plants from Japan. In 1908, Dr. LYON, then working with the Hawaiian Sugar Planters Association observed large numbers of these larvae at the base of cane plants but mistook them for the Japanese beetle of Hawaii (*Adoretus tenuimaculatus* Water.). In 1912, Dr. A. SPEAR, in studying the fungous diseases of insects affecting sugar-cane in Hawaii collected a number of these larvae and turned them over to Mr. F. MUIR, who recognized them as a species new to the Island. In June of that year Mr. Muir visited the infested fields and collected adults; the pest though infecting but a small area was extremely destructive, and the Hawaiian Sugar Planters Association

detailed a specialist to proceed to the Orient and obtain parasites for the control of this pest. This work was so successful that one of the parasites (*Scolia manilae* Ashm.) was established between the years of 1914–16 and by 1919 had so thoroughly controlled this pest that from an area where in 1917, 3,500 *Anomala* grubs were collected in 1919 only four grubs were found by most diligent searching. The parasite has extended its range beyond the area infested by the *Anomala* and is now infesting the Japanese beetle of Hawaii. That the *Anomala* is established in Connecticut seems evident as specimens have been collected in the same nursery two successive years.

Dr. BAKER discussed a species of aphid in Baltic Amber.

Dr. ALDRICH made some remarks on *Lucilia* species. He reported *Onesia agilis* Meigen, a European genus new to the country. It is a scavenger and has been reared several times by Mr. THEODORE H. FRISON at the Japanese Beetle Laboratory.

Mr. ROHWER exhibited the nest of *Pseudomasaris vespoides* (Cresson) which had recently been received from Mr. L. H. WELD. The nest was composed of five cells, four of which produced the vespid and one a chrysidid parasite belonging to the section *Gonochrysis*. The nest of this wasp was first observed by DAVIDSON and more recently by Professor COCKERELL. This is the first complete nest in the National collection of this kind.

Mr. ROHWER exhibited the resin and pebble nest of one of the bees belonging to the genus *Dianthidium*. This nest was attached to an oak twig and was recently collected by Mr. L. H. WELD in California. It resembles closely the nest of *D. arizonicum* Rohwer, recently illustrated by Mr. MIDDLETON, but was so heavily parasitized by a chalcid of the genus *Monodontomerus* that none of the bees had emerged.

Mr. BUSCK read the following paragraph from the report of the Swedish botanist Pehr Kalm, a student of Linnaeus, who made what was probably one of the first scientific expeditions to North America, in the middle of the eighteenth century.

"I came unconsciously near bringing a great misfortune upon Europe. At my departure from America I brought with me a small package of sweet peas that looked very good and sound. On August 1, 1751, some time after I had arrived in Stockholm, I opened the package and found all the peas worm-eaten. From the hole in each pea an insect was peeking out, and some crawled into the open intending to try the new climate. I was glad to close the package again instantaneously and thus prevent the escape of these destructive creatures; and I must confess that when I first opened the package and saw those insects I was more frightened than if I had found a poisonous snake in it, for I knew what damage might have been wrought in my fatherland if but two or three of them had escaped. Many coming generations in many places would then have had reason to pass condemnation on me for causing so much misfortune."

Mr. ROHWER in discussing Mr. Busck's remark pointed out that with all the precaution of the early naturalists they had not been successful in keeping American insects out of Europe and gave as an example the Douglas fir seed chalcid *Megastigmus spermotrophus* Wachtl, a species which was first described from the material secured in Denmark from American seeds. This seed chalcid is a much greater pest in Europe than it is in America.

Mr. GAHAN gave the following note on the distribution of the clover chalcid, *Bruchophagus funebris* (How.): *America*, in clover, alfalfa and astragalus;

Chile, in wild alfalfa; *Omsk*, *Siberia*, in alfalfa seed; *Manchuria*, in seeds of Trifolium; *Cape Town*, South Africa, from seeds of lucerne or alfalfa.

J. C. BRIDWELL announced the recovery of *Kytorhinus karasini* Fischer v. Waldheim (1808), type of the genus *Kytorhinus* Fischer, which has not been recognized since its description. It was originally described from the seeds of *Robinia* (now *Caragana*) *jubata* from the Altai Mts. in Central Asia. The genus *Kytorhinus* has been represented by species in the Mediterranean region, the Caucasus, Central Asia, and a species was described by Dr. Sharp as the type of his genus *Pygobruchus*. The material in question was found by the inspectors of the Federal Horticultural Board in seeds of a species of *Caragana* (possibly *jubata*) which occurs in Szechuen Province, China, from which the material was sent to the Foreign Seed and Plant Introduction Office of the Bureau of Plant Industry, and there are in the U. S. National Museum a new species of the genus from India and one from China received in this manner. A Canadian species of the genus has been recently discovered in material collected by Mr. F. C. CARR at Edmonton, Alberta. This is the first authentic instance of a mylabrid genus (in the narrower sense) common to the old and new worlds. Descriptions of the new species have been prepared for publication.

Dr. SCHWARZ said that species collected in South America many years ago by DARWIN are now only partly named. Dr. SCHWARZ also stated that the first scientific expedition in South America was made by the French engineer CONDERMAINE about 1770. His main object was to measure the equator. He went from Ecuador to the Rio Napo River. The second scientific expedition was by HUMBOLDT and BONPLAND. They went down the Orinoco to Ecuador mainly to investigate the high volcanoes.

CHAS. T. GREENE, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Closer cooperation between the weather observation stations in the Bahamas and the Weather Bureau of the United States Department of Agriculture is being established in connection with the hurricane-warning work. Mr. BENJAMIN C. KADEL, a meteorologist from the U. S. Weather Bureau, has been sent to Nassau and to Inaugua, in the Bahamas, to assist in this work.

Excavations for a new hotel building at Connecticut Avenue and De Sales Street in Washington have uncovered the stumps and residues of a Tertiary forest of cypress of considerable geological interest.

ERNST G. FISHER, chief mechanical engineer in the U. S. Coast and Geodetic Survey, retired from the service August 5, 1922, after over thirty-five years of active work for the Government.

JOSEPH W. GRIEG, recently assistant in the department of mineralogy at Columbia University, has been added to the staff of the Geophysical Laboratory, Carnegie Institution of Washington, as a petrologist.

JOHN B. HENDERSON, a Regent of the Smithsonian Institution, has purchased for the Division of Mollusks the General Evezard Collection of mollusks estimated at from 7,000 to 10,000 specimens, including a large number of types. General Evezard lived in western India for twenty-eight years, and being interested chiefly in mollusks made large collections of those animals.

Professor A. S. HITCHCOCK, Custodian of Grasses at the National Museum, is giving a course on taxonomic botany in the graduate School for Department Workers, U. S. Department of Agriculture.

ELLSWORTH P. KILLIP, Aid in the Division of Plants, U. S. National Museum, returned in October from a botanical collecting trip of six months in Colombia organized by the New York Botanical Garden, the Gray Herbarium, the Philadelphia Academy of Natural Sciences, and the National Museum.

Dr. AUGUST KROGH, oceanographer, Copenhagen, Denmark, winner of the Nobel Prize in medicine, 1920, is visiting in Washington, and lectured before the Entomological Society November 8.

C. P. LOUNSBURY, entomologist of the Union of South Africa, who has been in official entomological work for twenty-six years at Cape Town, is visiting the United States and has recently been at the National Museum and Department of Agriculture. Mr. Lounsbury is a New Englander by birth and a graduate of the Massachusetts Agricultural College.

W. W. RUBEY, assistant geologist of the U. S. Geological Survey, has been granted leave of absence to accept an instructorship at Yale University for the current year.

Dr. GEORGE OTIS SMITH has resigned as director of the U. S. Geological Survey in order to qualify as a member of the Coal Commission appointed by the President. Dr. PHILIP S. SMITH has been appointed acting director in the interim.

DAVID WHITE, who completes ten years' service as chief geologist in the U. S. Geological Survey on November 16, will be relieved of that duty at his own request and W. C. MENDENHALL, for more than ten years the geologist in charge of the Land Classification Board, will be made chief geologist. Mr. Mendenhall will be succeeded as chief of the Land Classification Board by HERMAN STABLER.

JOURNAL

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GENERAL SCIENCE.—*A first revised edition of the Academy's list of one hundred popular books in science.*[1] ROBERT B. SOSMAN, Chairman of the Committee on Popular Books in Science.

In the latter part of 1920 Dr. George F. Bowerman, Librarian of the Public Library of the District of Columbia, suggested to the Board of Managers of the ACADEMY the desirability of having an authorized list of popular and at the same time reliable books in science which he could recommend to his readers. The Board thought well of the suggestion and appointed the President and resident Vice-Presidents, representing the fourteen affiliated societies, as a committee to prepare such a list. The writer, at that time Secretary of the ACADEMY and one of the editors of its *Journal*, was appointed editor of the list.

Part of the work was assigned to the members of the Committee, and the assistance of a number of other resident and non-resident members of the ACADEMY was also requested. The material thus compiled was prepared in the form of a preliminary report and distributed in July, 1921 for criticism. Between fifty and sixty persons cooperated, through correspondence or by personal interview, in revising this preliminary list.

The list, which then numbered somewhat over one hundred, was reduced to an even hundred by elimination of the titles which were most in doubt, and the books were grouped with accompanying notes so as to make of the whole a continuous-reading unit. This was published in the *Journal*,[2] and the books themselves were placed on view at a meeting of the ACADEMY at the Public Library on October 20, 1921, at which additional criticisms and suggestions were received.

Offprints of this preliminary publication were distributed to many libraries by Dr. Bowerman, and some useful comments and suggestions were received. It was also reprinted in the Public Library's

[1] Received November 23, 1922.

[2] This JOURNAL 11: 353–366. September 19, 1921.

bulletin and has subsequently been copied elsewhere. The widespread interest indicated in such a list led Dr. Bowerman to suggest that it be published by the American Library Association in a form available for libraries in general, and the preliminary edition above referred to has therefore been revised with that end in view.

REVISION OF THE LIST

A new committee, consisting of the President and resident Vice-Presidents for the current year, with the writer as chairman, was appointed. As a preliminary to this revision the list, condensed to author and title only, was sent to all members of the ACADEMY in the form of a ballot in December, 1921. The ballot also contained, in addition to the one hundred, forty-five titles which had been favorably recommended to the Committee. The request heading the ballot was as follows:

"The committee in charge of the selection wishes to obtain the best possible list, and will welcome your opinion on the books already selected, and your suggestions as to changes which would improve the list.

Specifications: (1) The book must be *readable;* if the average visitor to the library takes the book home, it will interest him so much that he will read it through, and will come back to ask the librarian for another on the same subject. (2) It must be *accurate;* preferably written by one who knows his subject at first hand. Minor points are: (3) up-to-dateness; (4) small bulk; (5) attractive binding, type, and illustrations.

The relative number of books in different branches of science is not fixed. For example, a good book in mathematics may be substituted for a poor book in anthropology, provided anthropology is not thereby left wholly unrepresented."

About one-fourth of the resident members responded with criticisms and new titles, and replies were also received from many non-resident members.[3] These ballots were made the basis of the new revision. The total number of books nominated and considered was 323.

A new feature of the revision which the first committee had not had to consider was the question whether books were in print. The larger libraries, when issuing reading lists, sometimes find it necessary to have many copies of a book on hand. Furthermore, copies are continually being worn out and replaced, so that for wide circulation it is important that the list contain only books which are readily

[3] It may be of interest in passing to note that the member of the ACADEMY who made the "highest score" as to the number of books read was the president of a large research institution, working in many fields of science. He had read, and gave opinions upon, fifty-two books out of the hundred. The member who came next in order was a man who had devoted most of his life to research in a relatively narrow specialty.

available. This problem has caused the removal of about twenty-five books from the preliminary list, and has required several minor revisions as further information was obtained regarding the possibility of reprinting or otherwise securing a supply of certain books. The Committee is indebted to Dr. Bowerman and the Library staff, as well as to the American Library Association, for handling the considerable volume of correspondence necessary in obtaining up-to-date information on availability, editions, paging, and prices.

THE IDEAL POPULAR SCIENCE LIST

The Committee recognizes that in giving opinions on the *readability* of scientific books it is going outside its proper province. Its true function should be to pass judgment on the *reliability* of the books. Their readability can be determined only by the reader, and the ultimate choice of such a list lies with him. The logical procedure would seem to be to take several hundred scientific books which are known to be popular simply because they are good reading, and select from among them the one hundred which are the most reliable scientifically. Unfortunately, the data for such a preliminary listing do not seem to exist. Perhaps the data are practically unobtainable, because of the large and unknown influence of the many ways, intentional or accidental, by which books are advertised. But this whole question of how books become popular is a problem outside the province of the Committee.

The Committee has done its best to select one hundred books which it feels fairly sure are scientifically reliable, and which it believes to be readable. The list is subject to revision, and indeed should be revised frequently to keep up with the progress of science and the publication of books better adapted to the purpose. The Committee will welcome opinions and suggestions looking toward a revision after a year or two of trial of the present list.

In general, it need hardly be said that even a tried and tested list can never be completely satisfactory, for the simple reason that there is no such person as the "average reader." Every individual has his own foundation of natural capacity and education, and his own background of experience and interests. We therefore need one series of lists covering all types of capacity, another series differentiated according to kind and duration of education, another series distributed according to age and to variety of experience, and still another adapted to the varied types of man's interests. Provided with such a set of

lists we could name twenty-five scientific books which would be almost certain to interest keenly any given individual. Lacking such provision, we can only hope, on behalf of the very general list herewith submitted, that every reader who can be induced to read anything at all serious will find on the list a few books which appeal to him strongly, and that none of the other books will give him the impression that science makes reading-matter which is difficult or forbidding.

BOOKS DROPPED FROM THE PRELIMINARY EDITION

The following books, which were in the preliminary list published in September, 1921, have been dropped for reasons briefly indicated:

ABBOTT, C. C. *Upland and meadow.* Out of print.

ABNEY, W. DE W. *Colour measurement and mixture.* Out of print. Not well adapted for popular reading.

Adolfo Stahl lectures in astronomy. Out of print.

AMES, J. S. *The constitution of matter.* Out of print.

BALL, R. S. *Time and tide.* Out of print.

BENNETT, L. F. *Rocks and minerals.* A manual, not a book adapted for reading.

BUCKLEY, A. B. *Life and her children.* Out of print.

COLE, G. A. J. *The changeful Earth.* Out of print.

CORNISH, V. *Waves of the sea and other water waves.* Out of print.

DARWIN, C. *The formation of vegetable mould through the action of worms.* Out of print.

DICKSON, H. N. *Climate and weather.* Out of print.

DWERRYHOUSE, A. R. *Geology.* Out of print.

GRATACAP, L. P. *A popular guide to minerals.* A manual, not adapted for reading.

HADDON, A. C. *The study of Man.* Out of print.

HALE, G. E. *The study of stellar evolution.* Out of print and replaced by a later book by the same author.

HARRINGTON, M. W. *About the weather.* Out of print.

HEADLEY, F. W. *Problems of evolution.* Out of print.

HERRICK, F. H. *Home life of wild birds.* Out of print.

KIDD, D. *Savage childhood. A study of Kafir children.* Out of print.

LOTSY, J. P. *Evolution by means of hybridization.* Considered by some to be too specialized for popular reading. Also difficult of importation, being a Continental book.

LUBBOCK, J. *Flowers, fruits and leaves.* Out of print.

MICHELSON, A. A. *Light waves and their uses.* Out of print.

PECKHAM, S. W., and PECKHAM, E. G. *Wasps, social and solitary.* Out of print.

PERRY, J. *Spinning tops.* Out of print.

SEELY, H. G. *The study of the Earth in past ages.* Written for British rather than American readers.

TALMAN, C. F. *Realm of the air.* (Title subsequently changed to *Meteorology, the science of the atmosphere.*) Part of a series which the publishers would not promise would be available singly.

THORPE, E. *History of chemistry.* A two-volume work. Also thought by some to be not well adapted for popular reading.

TYNDALL, J. *Fragments of science.* Now obtainable only as two volumes; some of the essays now out of date and incorrect in certain particulars.

WHETHAM, W. C. D. *The recent development of physical science.* Out of print.

The following titles were put on the revised edition for 1922, but had to be removed subsequently because they were found to be out of print:

HEADLEY, F. W. *Life and evolution.*

LE CONTE, J. *Sight: An exposition of the principles of monocular and binocular vision.*

SHALER, N. S. *Aspects of the Earth.*

STERNBERG, C. H. *The life of a fossil hunter.*

It may be that some of the books contained in the two lists above are much better adapted for popular reading than some of the books on the revised list. The Committee would be grateful to any reader of this report for having its attention called to such books, because if they are badly needed there is a possibility of having them reprinted, either by the original publisher or through agreement with some other publisher who may be willing to assume the risk for the sake of aiding in making available first-class popular science.

As the complete "first revised edition" of 1922 will soon be obtainable through the American Library Association and will probably be distributed by several large libraries, it hardly seems worth while to reprint here the full list with accompanying notes and connecting paragraphs. For convenience of reference, however, the authors and titles of this latest edition are reprinted below:

General science:

1. THOMSON, J. ARTHUR, Editor. *The outline of science.*
2. HUXLEY, THOMAS HENRY. *Selections from Huxley.*

Man:

3. THORNDIKE, EDWARD L. *The Human Nature Club.*
4. JAMES, WILLIAM. *Psychology.*
5. WOODWORTH, ROBERT S. *Psychology; a study of mental life.*

6. OSBORN, HENRY FAIRFIELD. *Men of the Old Stone Age; their environment, life and art.*
7. MASON, O. T. *The origins of invention.*
8. MASON, O. T. *Woman's share in primitive culture.*
9. HOUGH, WALTER. *The Hopi Indians.*
10. MCCOLLUM, E. V. *The newer knowledge of nutrition.*
11. SHERMAN, H. C. *Food products.*
12. EDDY, WALTER H. *The vitamine manual; a presentation of essential data about the new food factors.*
13. JORDAN, E. O. *Food poisoning.*
14. KEEN, WILLIAM WILLIAMS. *Medical research and human welfare.*
15. HUNTINGTON, ELLSWORTH. *Civilization and climate.*

Heredity:

16. DARWIN, CHARLES. *The origin of species.*
17. EAST, E. M., and JONES, D. F. *Inbreeding and outbreeding.*
18. CASTLE, W. D., COULTER, J. M., DAVENPORT, C. B., EAST, E. M., and TOWER, W. L. *Heredity and eugenics.*
19. MORGAN, T. H. *A critique of the theory of evolution.*
20. CONKLIN, E. G. *Heredity and environment.*
21. GALTON, FRANCIS. *Hereditary genius.*
22. POPENOE, PAUL, and JOHNSON, R. H. *Applied eugenics.*

Biology:

23. THOMSON, J. ARTHUR. *The wonder of life.*
24. THOMSON, J. ARTHUR. *The haunts of life.*
25. BOUVIER, E. L. *The psychic life of insects.*
26. CURTIS, WINTERTON C. *Science and human affairs.*
27. LOCY, WILLIAM A. *Biology and its makers.*

Zoology:

28. BUCKLEY, A. B. *The winners in life's race.*
29. NELSON, E. W. *Wild animals of North America.*
30. ROOSEVELT, THEODORE. *African game trails.*
31. BEEBE, C. W. *Jungle peace.*
32. STONE, WITMER, and CRAM, W. E. *American animals; a popular guide to the mammals of North America north of Mexico.*
33. CHAPMAN, FRANK M. *Camps and cruises of an ornithologist.*
34. FABRE, J. H. *Social life in the insect world.*
35. MAETERLINCK, MAURICE. *The life of the bee.*
36. JENKINS, OLIVER P. *Interesting neighbors.*
37. BLATCHLEY, W. S. *Gleanings from Nature.*
38. MAYER, ALFRED G. *Sea-shore life.*

Botany:

39. GANONG, W. F. *The living plant; a description and interpretation of its functions and structure.*

40. OSTERHOUT, W. J. V. *Experiments with plants.*
41. SORAUER, PAUL. *A popular treatise on the physiology of plants for the use of gardeners or for students of horticulture and agriculture.*
42. HARDY, MARCEL E. *The geography of plants.*
43. DARWIN, CHARLES. *Insectivorous plants.*
44. TOWNSEND, C. W. *Sand dunes and salt marshes.*

Microscopic life:

45. VALERY-RADOT, RENÉ. *Louis Pasteur, his life and labours.*

Paleontology:

46. LUCAS, F. A. *Animals of the past.*
47. HUTCHINSON, H. N. *Extinct monsters and creatures of other days; a popular account of some of the larger forms of ancient animal life.*

Geology and geography:

48. GREGORY, J. W. *Geology of to-day.*
49. HAWKESWORTH, HALLAM. *The strange adventures of a pebble.*
50. LULL, R. S., and others. *The evolution of the Earth and its inhabitants.*
51. CHAMBERLIN, T. C. *Origin of the Earth.*
52. GEIKIE, ARCHIBALD. *The founders of geology.*

52A.[4] MERRILL, GEORGE P. *The first one hundred years of American geology.*

53. SEMPLE, ELLEN CHURCHILL. *Influences of geographic environment.*
54. SPURR, J. E., Editor. *Political and commercial geology and the world's mineral resources.*
55. BRIGHAM, ALBERT P. *Geographic influences in American history.*

Geologic agents:

56. TYNDALL, JOHN. *The forms of water in clouds and rivers, ice and glaciers.*
57. BONNEY, T. G. *The work of rains and rivers.*
58. BONNEY, T. G. *Volcanoes, their structure and significance.*
59. RUSSELL, ISRAEL C. *Volcanoes of North America.*
60. DAVISON, CHARLES. *The origin of earthquakes.*

Meteorology:

61. LEMPFERT, R. G. K. *Weather science.*
62. WARD, R. DE C. *Climate, considered especially in relation to Man.*

The ocean:

63. MURRAY, JOHN. *The ocean.*

Rocks and minerals:

64. COLE, GRENVILLE A. J. *Rocks and their origins.*

Astronomy:

65. BALL, ROBERT S. *The story of the heavens.*
66. DYSON, F. W. *Astronomy.*
67. HALE, GEORGE E. *The new heavens.*
68. ABBOT, CHARLES G. *The Sun.*

[4] Now out of print, but will be reprinted in 1923, when it will replace no. 52.

69. LEWIS, ISABEL M. *Splendors of the sky.*
70. MCKREADY, KELVIN. *A beginner's star book.*
71. TURNER, H. H. *A voyage through space.*
72. BERRY, ARTHUR. *A short history of astronomy.*

Chemistry:

73. SLOSSON, E. E. *Creative chemistry.*
74. HENDRICK, ELLWOOD. *Everyman's chemistry.*
75. FULLER, HENRY C. *The story of drugs.*
76. FABRE, JEAN HENRI. *The wonder book of chemistry.*
77. DUNCAN, ROBERT KENNEDY. *The chemistry of commerce.*
78. MARTIN, GEOFFREY. *Modern chemistry and its wonders.*
79. SODDY, FREDERICK. *The interpretation of radium.*
80. VENABLE, F. P. *A short history of chemistry.*
81. SMITH, EDGAR FAHS. *Chemistry in America.*

Physics:

82. SODDY, FREDERICK. *Matter and energy.*
83. MILLS, JOHN. *Within the atom.*
84. EINSTEIN, ALBERT. *Relativity.*
85. FLEMING, J. A. *Waves and ripples in water, air, and aether.*
86. MILLER, DAYTON C. *The science of musical sounds.*
87. BRAGG, WILLIAM. *The world of sound.*
88. LUCKIESH, MARION. *Color and its applications.*
89. BOYS, C. V. *Soap bubbles: their colours and the forces which mould them.*
90. MACH, ERNST. *Popular scientific lectures.*
91. SODDY, FREDERICK. *Science and life.*

Mathematics:

92. WHITEHEAD, A. N. *Introduction to mathematics.*
93. CONANT, LEVI LEONARD. *The number concept, its origin and development.*
94. YOUNG, JOHN WESLEY. *Lectures on the fundamental concepts of algebra and geometry.*
95. SHAW, JAMES BYRNIE. *Lectures on the philosophy of mathematics.*
96. DE MORGAN, AUGUSTUS. *On the study and difficulties of mathematics.*
97. SMITH, DAVID EUGENE. *Number stories of long ago.*

History of science:

98. LIBBY, WALTER. *An introduction to the history of science.*
99. SEDGWICK, W. T., and TYLER, H. W. *A short history of science.*
100. WHITE, ANDREW D. *A history of the warfare of science with theology in Christendom.*

SCIENTIFIC NOTES AND NEWS

L. B. ALDRICH of the Smithsonian Institution is taking charge of the solar observing station at Montezuma, Chile, probably until 1925.

Dr. L. M. ESTABROOK of the Bureau of Agricultural Economics, Department of Agriculture, will leave in January for the Argentine, the government of which has asked him to reorganize the economic and statistical work of the similar department in that country. During his absence his work will be in charge of W. F. Callander.

Dr. ALES HRDLICKA has returned from a trip to South America and Europe. In Europe he was enabled to visit a number of important sites, some of them new, of finds of Early Man, and to personally examine all the skeletal remains of ancient man discovered since his European visit in 1912. Among them were the remains of the Piltdown Man, and the Rhodesian skull recently discovered in South Africa.

The Petrologists' Club met on Tuesday, November 28. Dr. F. E. WRIGHT of the Geophysical Laboratory, Carnegie Institution of Washington, gave an informal illustrated talk on *A geologic trip to South Africa.*

The National Research Council has appointed the following committee to examine the project for the establishment of a tropical research station in Panama: NEVIN M. FENNEMAN (Chairman), *Chairman of the Division of Geology and Geography;* HENRY S. GRAVES, *Chairman of the Division of States Relations;* FREDERICK P. GAY, *Chairman of the Division of Medical Science:* RAYMOND DODGE, *Chairman of Anthropology and Psychology;* and VERNON L. KELLOGG, *Permanent Secretary of the Council.*

INDEX TO VOLUME 12

An * denotes an abstract of a published paper. A † denotes an abstract of a paper presented before the ACADEMY or an affiliated Society. A § indicates an item published under the head Scientific Notes and News.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

AUTHOR INDEX

SUBJECT INDEX

CONTENTS

Original Papers

Abstracts

Proceedings

ANNOUNCEMENTS OF MEETINGS

Tuesday, January 10. The ACADEMY, at the Cosmos Club. Program:

Address of the Retiring President, ALFRED H. BROOKS: *The scientist in the Federal Service.*

Tuesday, January 10. The Institute of Electrical Engineers.

Wednesday, January 11. The Geological Society, at the Cosmos Club, at 8 p.m.

Thursday, January 12. The Chemical Society.

Saturday, January 14. The Philosophical Society.

Tuesday, January 17. The Anthropological Society.

Wednesday, January 18. The Society of Engineers.

CONTENTS

Original Papers

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, January 21. The Biological Society.

Wednesday, January 25. The Geological Society.

Wednesday, January 25. The Medical Society.

Saturday, January 28. The Philosophical Society.

Wednesday, February 1. The Society of Engineers.

Wednesday, February 1. The Medical Society

Saturday, February 4. The Biological Society.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Wednesday, January 4. The Biological Society, at the National Museum at 8.15 p. m., in cooperation with the Audubon Society and Wild Flower Preservation Society. Program: ARTHUR C. PILLSBURY: *Wild flowers and birds of Yosemite National Park.*

Thursday, January 5. The Entomological Society, at the National Museum, at 8.00 p. m. Program: W. R. WALTON, presidential address: *The entomology of English poetry.*

Tuesday, January 10. The ACADEMY, at the Carnegie Institution, at 8.15 p. m. Program: ALFRED H. BROOKS, presidential address: *The scientist in the Federal Service.*

[1] Received too late for publication before the date of the meeting.

CONTENTS

ORIGINAL PAPERS

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, February 7. The Botanical Society.

Wednesday, February 8. The Geological Society.

Wednesday, February 8. The Medical Society.

Thursday, February 9. The Chemical Society.

Saturday, February 11. Joint meeting of Academy and Philosophical Society.

Tuesday, February 14. The Society of Electrical Engineers.

Wednesday, February 15. The Society of Engineers.

Wednesday, February 15. The Medical Society.

Thursday, February 16. The ACADEMY.

Saturday, February 18. The Biological Society.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Tuesday, January 10. Joint Meeting of American Society of Mechanical Engineers and American Institute of Electrical Engineers, at the Interior Department, at 8 p.m. Program: HENRY FLOOD, JR.: *The super-power system.* L. E. IMLAY: *Hydro-electric developments.* N. W. STORER: *The super-power system from the standpoint of electrification.*

Thursday, February 2. Joint meeting of the ACADEMY and the Geological Society, at the Cosmos Club, at 8 p.m. Program: H. A. BROUWER, of the University of Delft: *The major tectonic features of the Dutch East Indies.*

[1] Received too late for publication before the date of the meeting.

CONTENTS

ORIGINAL PAPERS

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, February 21. The Anthropological Society.
Wednesday, February 22. The Geological Society.
Saturday, February 25. The Philosophical Society.
Wednesday, March 1. The Society of Engineers.
Thursday, March 2. The Entomological Society.
Saturday, March 4. The Biological Society.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Thursday, January 12. The Chemical Society, at the Cosmos Club, at 8 p.m. Program: WM. BLUM (Presidential Address): *Researches on the electrodeposition of metals, with reference to the electrotyping and electroplating industries.*

Tuesday, January 17. The Anthropological Society, at the National Museum, at 4.45 p.m. Program: F. WILSON POPENOE: *Identifying Guatemalan Indians by their costumes.*

Saturday, January 21. The Biological Society, at the Cosmos Club, at 8 p.m. Program: S. F. HILDEBRAND: *Fish in relation to mosquito control.* H L. SHANTZ: *Notes on the white ants of Africa.* C. D. MARSH: *Livestock poisoning by deathcamas.*

Saturday, January 28. Joint meeting of the ACADEMY and the Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program: L. T. TROLAND: *Psychophysics as the key to metaphysics.*

Thursday, February 2. The Entomological Society, at the National Museum, at 8 p.m. Program: R. E. SNODGRASS: *The fall webworm.* J. S. WADE: *On the entomological publications of the United States Government.*

Saturday, February 4. The Biological Society, at the Cosmos Club, at 8.15 p.m. Program: SMITH RILEY: *The Nation's game-supply.* A. H. HOWELL: *The relationship and distribution of American chipmunks.* VERNON BAILEY: *Raising baby beavers.*

[1] Received too late for publication before the date of the meeting.

CONTENTS

Original Papers

Abstracts

(See note, 136).

Proceedings

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, March 7 The Botanical Society

Wednesday, March 8 The Geological Society

Thursday, March 9 The Chemical Society, at the Cosmos Club, at 8 p m
  Program

  P. L. Gile *Soil colloids*

  C S. Scofield *The effect of alum on silicate colloids*

Saturday, March 11 The Philosophical Society

Tuesday, March 14 The Society of Electrical Engineers

Wednesday, March 15 The Entomological Society

Thursday, March 16 The Academy

Saturday, March 18 The Biological Society

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Thursday, February 16 Joint meeting of the Academy and the Anthropological Society, at the Cosmos Club, at 8 15 p m Program H V Sverdrup *Customs of the Chukchi natives of northeastern Siberia*

Saturday, February 18 The Biological Society, at the Cosmos Club at 8 p m Program R M Yerkes *The behavior of monkeys and apes*

[1] Received too late for publication before the date of the meeting

CONTENTS

Original Papers

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, March 21. The Anthropological Society.

Wednesday, March 22. The Geological Society.

Saturday, March 25. The Philosophical Society.

Saturday, April 1. The Biological Society.

Tuesday, April 4. The Botanical Society.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Monday, February 20. The Geological Society, at the Cosmos Club. Program: H. D. MISER and C. S. ROSS: *Diamond-bearing peridotite in Arkansas.*

Tuesday, February 21. The Anthropological Society, at the National Museum, at 4.45 p.m. Program: J. C. MERRIAM: *The ultimate significance of the Calaveras skull.*

Thursday, March 2. The Entomological Society, at the National Museum, at 8 p.m. Program: *Notes and exhibition of specimens.*

Saturday, March 4. The Biological Society, at the Cosmos Club, at 8 p.m. Program: VERNON BAILEY: *The raising of baby beavers.* PAUL BARTSCH: *The American shipworms and their economic importance.*

Tuesday, March 7. The Botanical Society, at the Cosmos Club, at 8 p.m. Program: RUDOLF KURAZ: *Fruit growing and forestry in Czecho Slovakia.* DAVID LUMSDEN: *Raising orchid seedlings by the use of a symbiotic mycorrhizal fungus.*

[1] Received too late for publication before the date of the meeting.

CONTENTS

Original Papers

Proceedings

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Wednesday, April 5. The Society of Engineers.

Thursday, April 6. The Entomological Society.

Saturday, April 8. The Philosophical Society.

Tuesday, April 11. The Society of Electrical Engineers.

Wednesday, April 12. The Geological Society.

Thursday, April 13. The Chemical Society, at the Cosmos Club, at 8 p.m. Program:

A. M. HOUGHTON: *What is a patent?*

W. B. JOHNSON: *The chemist and the Patent Office.*

Saturday, April 15. The Biological Society.

Tuesday, April 18. The Anthropological Society.

Wednesday, April 19. The Society of Engineers.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Thursday, March 16. Joint meeting of the ACADEMY and the Chemical Society, at the Cosmos Club, at 8.15 p m Program: R. B. MOORE: *The rare gases: their history, properties, and uses.*

Saturday, March 18. The Biological Society, at the Cosmos Club, at 8 p m. Program: PAUL BARTSCH: *The American shipworms and their economic importance.* IVAR TIDESTROM: *The floral alphabet of the Celts.*

[1] Received too late for publication before the date of the meeting.

CONTENTS

Page

Original Papers

Proceedings

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Thursday, April 20. The ACADEMY, at the Cosmos Club, at 8 p.m.

Saturday, April 22. The Philosophical Society.

Wednesday, April 26. The Geological Society.

Saturday, April 29. The Biological Society, at the Cosmos Club, at 8 p.m.

Program:

W. E. RITTER: *The usefulness and the peril of laboratory methods in biology.*

Tuesday, May 2. The Botanical Society.

Thursday, May 4. The Entomological Society.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Wednesday, March 29. Joint meeting of the ACADEMY, the Philosophical Society, and the Chemical Society, at the Cosmos Club, at 8 p.m. Program: F. W. ASTON: *Isotypes and the structure of the atom.*

Saturday, April 1. The Biological Society, at the Cosmos Club, at 8 p.m. Program: P. L. RICKER: *Wild flowers that need protection.* J. W. GIDLEY: *Hunting fossil vertebrates in southeastern Arizona.*

Thursday, April 6. The Entomological Society, at the National Museum, at 8 p.m. Program: *Notes and exhibition of specimens.*

[1] Received too late for publication before the date of the meeting.

CONTENTS

Original Papers

PROCEEDINGS

OFFICERS OF THE ACADEMY

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, May 6. The Philosophical Society.

Tuesday, May 9. The Institute of Electrical Engineers.

Wednesday, May 10. The Geological Society.

Thursday, May 11. The Chemical Society.
Program:
H. C. FULLER: *The chemist and the druggist.*

Saturday, May 13. The Biological Society.

Thursday, May 18. The ACADEMY.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Tuesday, April 11. The Institute of Electrical Engineers, at the Cosmos Club, at 7.45 P.M. Program: O. C. MERRILL. *Power development of the Colorado River and its relation to irrigation and flood control.*

Saturday, April 15. The Biological Society, at the Cosmos Club, at 8 P.M. Program: R. W. SHUFELDT: *Observations on the flora and fauna of the District of Columbia* R. P. COWLES: *A hydrographic and biological survey of Chesapeake Bay.*

Tuesday, April 18. The Anthropological Society, at the National Museum, at 4 45 P.M. Program: *Annual meeting for election of officers.*

[1] Received too late for publication before the date of the meeting.

CONTENTS

Original Papers

PROCEEDINGS

OFFICERS OF THE ACADEMY

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, May 20. The Philosophical Society.

Wednesday, May 24. The Geological Society.

Saturday, May 27. The Biological Society.

Thursday, June 1. The Entomological Society.

SPECIAL NOTICE

Members of the Chemical Society will make an excursion to the Endless Caverns near New Market, Virginia, in the Shenandoah Valley, leaving Union Station, Washington, Sunday, June 11, at 8.00 a.m., returning the same day. These caverns are extensive and are said to contain many remarkable geological formations. The railway rate is $2.50 round trip, motor conveyance $1.00. Dinner at the Caverns, if desired, $1.00. Members of the ACADEMY and affiliated societies and their friends are cordially invited to join in the excursion. The train arrives at 12.15; returning, leaves New Market 6.00 p.m., arriving at Washington 10.15 p.m.

CONTENTS

ORIGINAL PAPERS

PROCEEDINGS

OFFICERS OF THE ACADEMY

President: W. J. HUMPHREYS, Weather Bureau.

Corresponding Secretary: FRANCIS B. SILSBEE, Bureau of Standards.

Recording Secretary: WILLIAM R. MAXON, National Museum.

Treasurer: R. L. FARIS, Coast and Geodetic Survey.

CONTENTS

Original Papers

Proceedings

OFFICERS OF THE ACADEMY

President: W. J. Humphreys, Weather Bureau.

Corresponding Secretary: Francis B. Silsbee, Bureau of Standards.

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CONTENTS

Original Papers

Proceedings

OFFICERS OF THE ACADEMY

President: W. J. Humphreys, Weather Bureau.

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CONTENTS

Original Papers

Proceedings

OFFICERS OF THE ACADEMY

CONTENTS

Original Papers

OFFICERS OF THE ACADEMY

CONTENTS

Original Papers

OFFICERS OF THE ACADEMY

CONTENTS

Original Papers

Proceedings

OFFICERS OF THE ACADEMY

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, October 21. The Philosophical Society.

Wednesday, October 25. The Geological Society.

Saturday, October 28. The Biological Society.

Thursday, November 2. The Entomological Society.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Saturday, October 7. The Philosophical Society at the Cosmos Club at 8 15 p m. Program: RAYMOND DAVIS: *Deciphering of charred paper records.* R W. G. WYCKOFF: *Crystal structure of ammonium chloride and hydrazine hydrochloride* W. W. COBLENZ: *Measurements of planetary radiation.*

Thursday, October 12. The Chemical Society at the Cosmos Club at 8.00 p.m. Program: P. E. PALMER: *Automatic control of industrial processes by gas analysis methods.*

[1] Notices received too late for publication before the date of the meeting

CONTENTS

Original Papers

Proceedings

OFFICERS OF THE ACADEMY

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, November 4. The Philosophical Society.

Tuesday, November 7. The Botanical Society.

Wednesday, November 8. The Geological Society.

Thursday, November 9. The Chemical Society.

Saturday, November 11. The Biological Society.

Thursday, November 16. THE ACADEMY.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Tuesday, October 17. The Anthropological Society at the National Museum at 8.00 p.m. Program: J. WALTER FEWKES: *A summer's field work at Mesa Verde.*

Thursday, October 19. Joint meeting of THE ACADEMY, the Biological Society and the Chemical Society at the Cosmos Club at 8.15 p.m. Program: H. J. HAMBURGER: *The increasing significance of chemistry in medical thought and practice.*

Saturday, October 21. The Philosophical Society at the Cosmos Club at 8.15 p.m. Program: WILLIAM BOWIE: *The meetings of the International Geodetic and Geophysical Union and of the International Astronomical Union.* ROBERT S. WOODWARD: *The compressibility of the Earth.*

Wednesday, October 25. The Geological Society at the Cosmos Club at 8.00 p.m. Program: E. S. LARSEN: *Origin of some corundum-bearing rocks.* EDWARD SAMPSON: *Ferruginous cherts of Notre Dame Bay, Newfoundland.* E. G. ZIES: *Fumarole minerals of the Katmai region.*

[1] Notices received too late for publication before the date of the meeting.

CONTENTS

ORIGINAL PAPERS

PROCEEDINGS

OFFICERS OF THE ACADEMY

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, November 21. The Anthropological Society.

Wednesday, November 22. The Geological Society.

Saturday, November 25. The Biological Society.

Saturday, December 2. The Philosophical Society.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Thursday, November 2. The Entomological Society, at the New National Museum, at 8 p.m. Program: C. P. LOUNSBURY: *Notes from South Africa.*

Saturday, November 4. The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program: F. WENNER: *The variation of metallic conductivity with electrostatic charge.* R. GILCHRIST: *A new determination of the atomic weight of osmium.* R. B. SOSMAN: *Theory of structure and polymorphism in silica.*

Tuesday, November 7. The Botanical Society, at the Cosmos Club, at 8 p.m. Program W. A. ORTON: *Physiatric botany.* F. E. KEMPTON: *Barberry eradication in the United States.*

Wednesday, November 8. Special meeting of the Entomological Society, at the New National Museum, at 8 p.m. Program: AUGUST KROGH. *The respiration of insects.*

Wednesday, November 8. The Geological Society, at the Cosmos Club, at 8 p.m. Program: C. A. MATLEY: *Notes on the Lameta formation of India and its dinosaurian remains.* A. C. SPENCER: *The geology of dam sites.* G. F. LOUGHLIN: *The ore deposits of Leadville.*

Thursday, November 9. The Chemical Society, at the Cosmos Club, at 8 p.m. Program: W. M. CORSE: *The mining and smelting of nickel ores.*

[1] Received too late for publication before the date of the meeting

CONTENTS

Original Papers

Proceedings

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, December 5. The Botanical Society.

Wednesday, December 6. The Society of Engineers.

Saturday, December 9. The Biological Society.

Wednesday, December 13. The Geological Society.

Thursday, December 14. The Chemical Society, at the Cosmos Club at 8 p. m. Program: W. M. CLARK: *Oxidation-reduction reactions.*

Saturday, December 16. The Philosophical Society.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Saturday, November 11. The Biological Society, at the Cosmos Club at 8 p. m. Program: E. D. BALL: *Importance of adequate training for biological work in the Government service.* G. N. COLLINS: *Maize and its wild relatives.* N. A. COBB: *Nematodes inhabiting trees.*

Saturday, November 18. The Philosophical Society, at the Cosmos Club at 8.15 p. m. Program: C. E. VAN ORSTRAND: *Deep-earth temperatures in the United States.* K. S. GIBSON and E. P. T. TYNDALL: *The visibility of radiant energy.*

Wednesday, November 22. The Geological Society, at the Cosmos Club at 8 p. m. Program: G. E. P. SMITH: *The effect of transpiration of trees on the ground-water supply.* A. LOCKE: *Outcrops and ore-deposits.* A. J. COLLIER: *Some features of the geology of the Little Rocky Mountains, Montana.*

Friday, November 24. Joint meeting of the Chemical Society with the Maryland Section in Baltimore. Program: A visit to the new plant of the American Sugar Refining Company. Short addresses by C. L. HETTINGER and M. B. SCOTT of that plant.

[1] Notices received too late for publication before the date of the meeting.

CONTENTS

ORIGINAL PAPERS

INDEX

OFFICERS OF THE ACADEMY

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, December 19. The Anthropological Society.

Wednesday, December 20. The Society of Engineers.

Thursday, December 21. The ACADEMY.

Saturday, December 23. The Biological Society.

Tuesday, January 2. The Botanical Society.

Wednesday, January 3. Society of Engineers.

Thursday, January 4. The Entomological Society.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Saturday, December 2. The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program: PAUL R. HEYL: *A remarkable formula for prime numbers and a method of determining the prime or composite nature of large numbers.* Reports of officers and committees.

[1] Notices received too late for publication before the date of the meeting.